TWENTY-NINTH REPORT

OF THE

BOARD OF TRUSTEES

OF THE

NEW HAMPSHIRE COLLEGE

OF

AGRICULTURE AND THE MECHANIC ARTS

DURHAM, NEW HAMPSHIRE

TO THE

NEW HAMPSHIRE LEGISLATURE

SEPTEMBER 1, 1908

PRINTED BY TELEGRAPH PUBLISHING CO., NASHUA.
BOUND BY GEORGE G. NEAL, DOVER.

TWENTY-NINTH REPORT OF THE BOARD OF TRUSTEES OF THE NEW HAMPSHIRE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS FOR THE TWO YEARS ENDING AUGUST 31, 1908.

To His Excellency the Governor and the Honorable Senate and House of Representatives of New Hampshire.

Durham, N. H., September 1, 1908.

I have the honor of transmitting herewith the report of the New Hampshire College of Agriculture and the Mechanic Arts for the two years ending August 31, 1908.

Yours respectfully,

CHARLES W. STONE,

President of the Board of Trustees.

REPORT OF THE PRESIDENT

DURHAM, N. H., September 1, 1908.

Hon. Charles W. Stone, President of the Board of Trustees:—

SIR:—This biennial report contains the following:

First. Detailed statements as to the financial condition and transactions of the College from July 1, 1906 to August 31, 1908, including the annual reports submitted to the United States Government, covering the administration of the Morrill, Hatch, and Adams funds. All financial reports have been audited by the College auditor and approved by the Board of Trustees. In addition, all reports of funds appropriated by the United States Government have been approved by government officials designated for that purpose.

Second. The College catalog.

Third. The 19th and 20th annual reports of the Agricultural Experiment Station, covering the two fiscal years July 1, 1906 to June 30, 1908 and the work of the station to September 1, 1908.

Fourth. Meteorological records July 1, 1906 to June 30, 1908.

NEW BUILDINGS.

Library.—Since the publication of the last biennial report the new Hamilton Smith Public Library of the New Hampshire College has been completed and equipped. The building is located on the high ground north-east of Thompson Hall and is one of the most beautiful and imposing buildings on the campus. It is of red pressed brick with buff Indiana trimmings and slate roof. It has ample reading and reference rooms, also seminar and study rooms and a large historical collection room, besides librarians' offices and a three story stack room with a capacity of sixty thousand volumes. The building cost $32,888 of which Mr. Andrew Carnegie furnished $20,000 and the Hamilton Smith estate of Durham $12,888. The equipment, costing $8,500, was provided by legislative appropriation. The consolidated library also receives the benefit of the invested funds of the Durham Library Association, and of the Durham Public Library. The library contains 23,000 volumes and is managed and maintained by the college for the free use of faculty, students, and citizens of Durham.

Smith Hall.—New Hampshire College is co-educational and has always admitted men and women upon equal terms. However, the attendance of young women has been comparatively small owing to the impossibility of providing suitable homes for them in Durham. This difficulty has been now overcome by the erection of Smith Hall, occupied September, 1908, with a competent matron in charge. This building was made possible by the generosity of Mrs. Shirley Onderdonk, of Durham, who gave $16,000 as a memorial to her mother, Mrs. Alice Hamilton Smith. The balance of the cost, $10,000, was provided by the state.

Smith Hall is a three and one-half story brick building, 86 feet long by 36 feet deep, built in "old English" style, with granite trimmings and gable roof, having a square vestibule projection over the main entrance and a piazza around the west end and a part of the north side. The main entrance faces the south and opens into a large hall-way.

On the right of the entrance is the dining room and to the left a handsome reception room. In the rear of the reception room are the office and apartments of the matron; back of the dining room are the serving room, kitchen and pantry. In the basement are the boiler room, trunk room, drying room, laundry, and rooms for storage and fuel. The second and third floors are for student accommodations, each floor being equipped to accommodate sixteen students, and provided with toilet rooms and baths (shower and tub).

The building is heated by steam and lighted by electricity. The interior finish is stained cypress, with hard wood floors.

The dormitory presents a fine appearance, and is a splendid addition to the college plant. In the future our women students will find, in Smith Hall, as comfortable and pleasant college accommodations as are provided anywhere in New England.

GIFTS.

Since the publication of the last biennial report the following gifts have been made to the College:

Andrew Carnegie, New York, Library	$20,000.00
Hamilton Smith Estate, Durham, N. H., Library	12,888.00
Mrs. Shirley Onderdonk, Durham, N. H., Woman's building	16,000.00
Robert P. Bass, Peterboro, N. H., Student loan fund	25.00
Pearson Estate, Concord, N. H., Student loan fund	600.00
Total	$49,513.00

STUDENT ENROLLMENT.

Year.	Total Enrollment.	Total 4 Yr. Classes.
1893	64	64
1894	108	91
1895	112	79
1896	105	84
1897	136	73
1898	99	71
1899	134	72
1900	139	79
1901	131	91
1902	111	98
1903	134	106
1904	159	118
1905	195	146
1906	212	164
1907	203	176
1908	225	192

NEEDS OF THE COLLEGE.

Creamery.—The creamery building, put up as a temporary wooden structure many years ago has reached a state of delapidation which will no longer permit of its being used as a place in which to give modern instruction in dairying. A suitable new building must be provided at the earliest possible date.

Engineering Building.—There is pressing need of a building in which to house the Departments of Mechanical and Electrical Engineering and Physics. These departments are now occupying the same space that they did when the college was first established at Durham, notwithstanding the fact that we now have three and one-half times as many students as we then had, and that our teaching force has been greatly enlarged. All of the engineering laboratories, class rooms, offices and shops are badly over crowded, with the deplorable result that the instruction given is not as efficient as it ought to be.

The Departments of Chemistry are seriously handicapped for space. It is a fact that not more than one-half the instruction in Chemistry is given that should be because of lack of desk and laboratory room. Every year many students are refused admission to the Chemical Engineering Course for this reason. For the same reason our Agricultural and General Course students are denied the privilege of taking advanced courses in Analytical

Chemistry. Given a new engineering building the whole of Conant Hall, the science building, would be set apart for Chemistry. Even with this arrangement only the immediate needs of the Chemical Department would be provided for.

An engineering building is absolutely necessary if we are to do creditable work in these important departments.

Water Supply and Sewerage.—The college buildings are now supplied with water from an open reservoir which furnishes an abundance of water suitable for boilers, watering plants and for fire protection. However, it is wholly unfit, and is not used, for drinking purposes. Drinking water is carried from nearby springs. Probably the boring of two or more wells near the power house would provide sufficient pure water for all ordinary college uses, leaving the reservoir water in reserve to be used in case of fire. The college needs pure water not only for drinking but for laboratory purposes as well.

The lack of a sewerage system in the village is a menace to the health of students and townspeople alike. Provision should be made at once for co-operation between the college and the village to remedy this evil.

Repairs of Buildings.—Many of the college buildings are badly in need of paint and other repairs. At least $1,000 should be spent on them next summer.

Grading.—The grading at the Library, Smith Hall, and Gymnasium has not been completed owing to the lack of funds. Provision should be made for these improvements at an early date.

Agricultural Department.—The Agricultural department is in great need of a piggery, a manure shed, and additional live stock.

Dynamo.—The dynamo which now supplies light for our buildings has been entirely outgrown. It has a capacity of but 500 lights. We have 1,200 lights in our buildings.

Athletic Field.—The athletic field has a good natural location but needs improving. A running track, covered grand stand, and a fence should be provided.

REPORTS OF HEADS OF DEPARTMENTS.

Department of Mathematics.

The most urgent need of the Mathematics Department is an assistant who shall devote his whole time to this specialty. Hitherto assistants in other departments have been drafted to hear special classes in mathematics. The work has been frag-

mentary and secondary, and the best results impossible. An instructor in mathematics should have special training in his subject and should be selected with reference to his ability to teach such special subject. Moreover, a thorough inspection of students' examples and tests requires more work than can possibly be done by the present teaching force.

The equipment for surveying will necessarily be increased the present year by the addition of a transit; other instruments will be required in the near future for our enlarged classes.

C. H. PETTEE,
Professor of Mathematics.

Department of History and Political Economy.

The Department of History and Political Economy was established as the result of certain changes made about fourteen years ago. In the work of the department were included several new courses and several old courses which I had given for about fifteen years. Among the latter were a course in Political Economy, a course in American Constitutional Law, a course in Business Law, and a course in American Literature. The larger part of the courses in History either was intended for preparatory students, or represented the work now done in good high schools.

Gradually the elementary courses in History have been replaced by advanced work suitable for students who have had the excellent historical courses now given in New Hampshire high schools. Also various changes have made the work of the department about fifty per cent. greater than it was when it was established.

The work of the department includes courses frequently divided among the departments of Economics, Political Science, European History and American History. In teaching nearly every one of the courses now given, there is need of persistent study and extensive reading. Under the present conditions of college work no one instructor can do justice to more than a part of them.

The present courses in American History, American Literature and American Constitutional Law compare fairly well with those given in the average New England college. The courses in European History allow the student to take the subject for two years. As the high schools now give three years to European History and as this college may be expected to prepare teachers for high school work, the courses in European History should, at

the least, be doubled. In fact, it is not unlikely that in a few years it may become necessary to establish a Department of European History.

There is need of additional courses in Political Science and particularly in Economics. The number of such courses that may be needed will depend somewhat upon the number of students desiring a General Course. I expect a large increase in the number of such students and in particular in the number of women students.

The number of students in my department this semester is fifty per cent. greater than the number in the department one year ago.

Respectfully presented,

C. W. SCOTT,

Professor of History and Political Economy.

Department of Organic Chemistry.

The department is in good condition at the present time and its immediate needs for the work in hand are small. A steam-bath and drying-oven in the Organic Laboratory would facilitate the work of the students in laboratory practice, as they are now obliged to use the outfit in the Quantitative Laboratory. Such an outfit would cost about $60 besides the labor and piping necessary for installation.

The most important need of the department is facilities for expansion. At the present time it is giving only required courses to Chemical and Agricultural students, some of which are also elective for General Course students. The number of students averages a little over one-third of each sophomore and junior class. There should be opportunity for elective courses for the Chemical students, since there is an enormous amount of material in pure and technical organic chemistry.

There is also no dividing line between organic chemistry and the subjects of plant and animal nutrition, for the advanced study of which the Agricultural students should have opportunities.

The department also carries the courses in Chemistry and Fertilizers of the Two Year Course. The lack of room is especially manifest with these classes in all attempts to arrange hour-plans because there is but one lecture room for all the chemical courses.

Respectfully submitted,

FRED W. MORSE,

Professor of Organic Chemistry.

Department of Inorganic Chemistry.

I desire to report that the Chemical Department of the college is in excellent condition and is crowded to the full extent of its capacity. In fact the greatest need which we have at the present time is larger laboratories and more facilities to meet the demand put upon us.

As is well known to those who are interested in the institution, the Chemical Department has been obliged for some years past to limit the number of students who can take up its special work owing to the fact that the state has not provided sufficient laboratory facilities and appliances to meet the demand. We are limited in the number of students we can handle simply by the number of laboratory desks which are available for use. At the present time there are thirty-six desks in the Qualitative Laboratory and there are many more students than desks, so that the instructors are worked at odd hours and many makeshifts have to be adopted to enable the students to procure the work which is required in their various courses.

In the Advanced Laboratory we are able now to take only such men as have selected the Chemical Course and we are obliged to limit these men to six from each class. It is highly desirable that men in other courses should have the privilege of electing a certain amount of advanced chemical work if they so desire, which is now denied them. This condition is not, however, unique in the Chemical Department, for all of the Engineering Departments are crowded with students to an extent incompatible with the facilities for properly handling their work.

Except for this crowded condition I feel that the Chemical Department is in fairly good condition. Its graduates are received for full post-graduate standing in any of the universities of the country, although the majority immediately go out into lucrative positions. In spite of the present depression in business, there is only one graduate of this department who is unemployed.

In addition to the teaching work the members of the staff and the Senior students have interested themselves so far as time would permit in research upon new chemical problems and a number of articles have been considered worthy of publication in our leading chemical journals, both at home and abroad.

The specific needs of the department are more laboratory space and lecture rooms for our present work and the apparatus and facilities which would be required therefor. It is also hoped that at no distant date the Trustees may find resources to es-

tablish an Assistant Professorship in Physical Chemistry with a laboratory fitted out to do more work along this line, which is becoming so prominent in the chemical life of the country.

I am

Respectfully yours,

CHARLES L. PARSONS,

Professor of Inorganic Chemistry.

Report of Agronomy Department.

On July 1st of this year the Department of Agriculture was subdivided into the Departments of Agronomy and Animal Husbandry. This division has been for the best interests of both departments since more detailed supervision can be given to the respective lines of work.

The work of the Agronomy Department is concerned mainly with soils, fertilizers and the production of field crops upon the college farm, together with the instruction given in these subjects in the regular collegiate and two year courses.

The college farm which is the practical laboratory for most of the courses of instruction consists of approximately 300 acres. Of this area about 30 acres are comprised in the college campus and athletic field. About 20 acres are used by the Horticultural Department and of the remaining 250 acres about 80 are in pasture, 70 in forest and 100 in tillable land. All of the arable fields are gradually increasing in productiveness and are now in a much better state of fertility than when the college first took possession of them eighteen years ago. From the fields where about forty tons of hay were cut at that time over one hundred tons are cut now.

Within the past four years a considerable amount of material and labor has been expended in the work of permanent farm improvement, such as the establishment of uniform size plots for experiment purposes, the laying out of farm roads, the removal of rocks, stumps and old stone walls, the construction of drains and ditches, the building of new fences and suitable housing quarters for a flock of 100 sheep. More than a mile of farm roads have been constructed which not only aid in the improvement of the farm but add greatly to the convenience of conducting field tests. Many of the old stone walls which divided the farm into small, irregular shaped fields have been removed and where possible, used in the construction of the roads. The size and shape of most of the fields have been altered so that a definite system of rotation can be followed, and in this

rearrangement much of the rough stony land formerly contained in fields has been thrown into pastures. Many of the open ditches which divided the fields and hindered cultivation have been closed with stones or tile, and in the entire work of drainage about two miles of tile have been used.

During the past two years a separate account of permanent farm improvements has been kept which shows that from July 1, 1906 to July 1, 1907, $1,092.04 and from July 1, 1907 to July 1, 1908, $1,576.01, a total in the two years of $2,668.05, was expended for this purpose. This work of improvement has just been well begun and continued funds and effort should be devoted to it in the future if the farm is to be made what a college farm ought to be.

Since it is the policy of the farm management to produce on the farm itself as much as possible of the hay and grain consumed by the live stock, and since the amount of land which is suitable for grain crops, especially field tests of them, is limited, and further because a considerable area has recently been apportioned for sheep pasturage, it is highly desirable that 20 or 30 acres additional tillable land be purchased or leased.

One of the most pressing and immediate needs of the Farm Department is a new horse barn with basement for the housing of wagons and implements. The old horse barn has stood the weather of almost countless summers and winters and is now in such a condition that repairs on it are a matter of false economy.

Another urgent need is the construction of two or three farm houses in which the farm laborers can live. At the present time one teamster lives a half mile from the college buildings and another more than three-quarters of a mile. During the past two years the farm foreman has had to live a full mile from his work. It is not for the best interests of the department to have its laborers living so far from their work for more reasons than one. In view of the fact that there are no houses in the village within a reasonable distance of the college which a farm laborer can afford to rent, it would seem like a good investment for the college to build dwellings of a modest design and reasonable cost and rent them to its workmen at a rate paying the interest on the investment.

Another need not of this department in particular, but of the whole Agricultural Department in general, is a suitable and permanent meeting place for the three agricultural societies, namely, the Agricultural Club, the Alpha Zeta fraternity and the Alpha Tau Alpha society of the two-year students. The fraternal,

social and literary spirit embodied in these organizations is of much value and importance to the students and should be encouraged in every way possible. The original plan of our agricultural building was to have the third story fitted and furnished as suitable quarters for these societies but up to the present time the work has not been done. It is estimated that about $1,500 would be required for the purpose.

F. W. TAYLOR,
Professor of Agronomy.

Department of Zoology.

I beg to present the following report of the Department of Zoology.

INSTRUCTION.—The classes given instruction during the year 1907-'08 were as follows:—

FALL TERM.

		Hours.	Students.
Zoology	1	3	16
Zoology	5	4	4
Zoology	11	4	1
Zoology	15	4	6
Geoolgy	2	3	6
Courses	5	18	33
	(8 rec. 10 Lab.)		

WINTER TERM.

		Hours.	Students.
Zool.	4	3	10
Zool.	40	1	7
Zool.	12	4	2
Zool.	14	4	6
Geol. Spec.		3	3
Courses	5	15	28
	(7 rec. 8 Lab.)		

SPRING TERM.

		Hours.	Students
Zool.	3	4	10
Zool.	13	4	2
Zool.	8	3	5
Zool.	14	4	6
Courses	4	15	23
	(7 rec. 8 Lab.)		

All the instruction in general Zoology, Physiology and Geology has been given by my assistant William Morton Barrows, (M. S. Harvard) in a most efficient manner. The writer with his assistant in Entomology, now Mr. C. F. Jackson, (M. S. Ohio St. Univ.), has given the instruction in the courses in entomology and advanced courses of special students. Satisfactory work in the elementary courses is hindered by having the class usually but three times a week. Two of these periods must be devoted to laboratory work, leaving but one period a week for class work of lectures, recitations, etc. One hour a week in the classroom is insufficient to cover the subjects taught, and the in-

frequency of attendance of the class makes it difficult to hold the attention of the student and arouse his interest. It is a question whether Zoology 1 and 3, required in the Agricultural Course, might not better be made elective and then more time allowed to those electing the course.

Equipment.—When the writer assumed charge of the department four years ago the Zoological collections were scattered around on open shelves and the geological collection was packed away. It has been my policy to secure cases and repair, remount, and label all specimens worthy of preservation as fast as the meagre funds of the department would permit. About $400 has been spent for cases, so that all the perishable specimens are in tight cases, though badly crowded. All specimens have been labelled and catalogued. The geological collection has been labelled, with each specimen in a tray and for the most part placed in a large case of drawers. Several more glass front wall cases are needed to house the collections now arranged on temporary shelving. The north-east room on the second floor of Thompson Hall, formerly occupied by the Drawing Department has been arranged as a museum room in which recitations are also held. The north-west room of the basement of Thompson Hall has been fitted as a laboratory for student work with spraying apparatus. All recitations are now held in the laboratory or in the museum room, neither of which are adapted for the purpose. In the near future a separate recitation room will be absolutely necessary.

The stereopticon is a most valuable aid in lectures, but until some arrangement can be made whereby electric power may be had more conveniently than at present, it is impracticable to make much use of it. Attention should also be called to the water supply, which is so filthy that it can be used only for cleaning purposes and often is totally unfit for photographic work, causing annoying inconvenience.

The department needs considerably more equipment by way of charts, models, and specimens, all of which will be secured as soon as funds may be made available. I would respectfully request that if possible the appropriation for the work of the department be somewhat increased over that of 1907-'08, in consideration of the decrease made necessary during the present fiscal year.

Respectfully submitted,

E. D. SANDERSON,

Professor of Zoology and Entomology.

Department of Physics.

The work of the Physics Department naturally falls under two heads:—

(a) The arrangement of studies and laboratory work to meet the needs of students who intend to become teachers of either physics or chemistry or both.

(b) To meet the needs of students who intend to take a course in pure science, whether it be with a view of continuing such a course after graduation or as a matter of training, or as a preparation to teach either physics or mathematics, or both.

The common features of both these subdivisions are a study of mathematics beyond the requirements of any of our present courses, as well as a thorough and consecutive study of the various branches of physics.

Under Class (a),

Inorganic, organic, theoretical and analytical chemistry, as well as the subdivisions of electro-chemistry are prominent and are absolutely necessary if a student is to be fitted to engage in the electro-chemical and electro-metallurgical industries.

This class requires a thorough grounding in electrical and chemical subjects, such as theoretical electricity including both direct and alternating current phenomena, an extended course in electrical measurements and testing, and a course in generator and motor testing with practice in handling machines for power distribution.

The chemical studies include analytical, theoretical, organic and industrial. Short courses in gas analysis, assaying, metallurgy, metallurgical laboratory, mechanism and steam engineering are included.

Under applied electro chemistry the student must be made familiar with the methods of handling electrolytic processes for deposition of metals, the care and use of storage batteries, the underlying principles and the construction and use of electric furnaces for the roasting and reduction of metals.

Under Class (b),

Upon the completion of the course in general physics, the subject is approached in detail from a theoretical and experimental side, and the courses being continuous are treated from a mathematical point of view.

The experimental work of this course should cover the greater

part of three years, and should be mainly devoted to physical measurements and investigations.

The laboratory work to be covered should be arranged so that each portion should be sufficiently isolated from any other that reliable results may be attained.

To do this provision should be made for laboratories as follows:

1. Laboratory for the study of the mechanics of solids, liquids and gases.

2. Heat Laboratory. Thermometry and Calorimetry; Coefficients of Expansion and Conduction; Vapor Pressures; Heating values of coals, fuels, etc.; Temperatures of kilns, flue gases, furnaces, etc.; Metallurgical Applications of Heat to Reduction Processes for reactions, etc.; Electrical Thermometry; Heat resisting materials, etc.

3. Light Laboratory. Gas Photometry, Lenses and Lens Combinations, microscopes, etc; Spectrum Analysis,—pneumatic diffraction and interference phenomena; Photographic methods, etc. Polarization of Light; Study of Light Waves, etc.; Electro Magnetic Theory of Light.

4. Elementary Electrical and Magnetic Laboratory.*

ROOMS AND OFFICES NEEDED.

1. Physical Lecture Room—seating 300.
   Sliding lecture desks — from lecture preparation room. Darkened by blinds; connected to steam and air pressure supplies; current mains, etc.
2. Apparatus and Lecture Preparation Rooms—for
   - Mechanics
   - Heat
   - Light
   - Sound
   - Electricity and Magnetism

   } 2 rooms, each 30′ by 40′
3. Physical Laboratory Rooms—
   1. Mechanics, 1 room, 60′ by 30′.
   2. Heat, 2 rooms, each 30′ by 20′.
   3. Light, 2 rooms, each 30′ by 20′.
   4. Sound, 1 room, 30′ by 20′.
   5. Electricity and Magnetic Measurements, 1 room, 50′ by 30′.

*Resistance measurements, e.m.fs. currents, polarization of cells, calibration of simple instruments for Chemical and Engineering students, electrostatic phenomena applied electro chemistry, study of accumulators, electro deposition, electric furnaces, electric discharges, radioactivity, magnetic phenomena.

These rooms should be connected to power, gas and water supplies, and have solid pillars, etc., where needed.

4. Storage Battery Room, 30′ by 15′.
5. Library and Reading Rooms, 2 rooms, each 30′ by 20′.
6. Photographic Room, 20′ by 15′.
7. Workshop—30′ by 20′.
8. Machinery Room—for small dynamos, motors, etc.

Substantial equipment of the Laboratories, Workshop, Machinery rooms, etc., is absolutely imperative in order that the work of the department may be up to the standard set by the other departments.

Respectfully submitted,

A. F. NESBIT.

Military Department.

I have the honor to submit the following report of the conditions and needs of the Military Department of this college, viz:—

CONDITION:—The following is from the official inspection report of Captain Peter C. Harris, General Staff, U. S. Army, dated May 25, 1908:—

"The military exercises included review, inspection, parade, company and battalion drill in close and extended order. The review and other ceremonies were well executed. The cadets march with good military step and preserve good alignment. * * * The arms and equipments were in good condition. The uniforms, with few exceptions, were neat and in very good condition. The close order battalion drill was very good and the extended order fairly good. The improvement noted in the report of last inspection has continued throughout the year."

In the three years I have been on duty here, the student feeling has changed from antipathy to pride and interest in things military. Instead of drudgery, the great majority of students, all, in fact, of the thinking students take pleasure in military work. Interest in rifle practice is keen as shown by the fact that over 50 per cent. of the battalion have been on the rifle range to shoot outside of the prescribed drill hours, with the result, that, using the same standard of classification as the National Guard of this and other states, three (3) sharpshooters and twenty-one (21) marksmen qualified.

The present organization is field, staff, band and three companies of infantry. The course of instruction covering three years, is shaped, per letter instructions from Adjutant General's

Office dated Washington, D. C., January 25, 1908, to "*qualify students who enter the military departments to be Company officers of Infantry Volunteers or Militia.*"

During my term of duty, drill hour has been changed from 4 p. m., (students' recreation hour) to 11 a. m.; credit given towards diploma for work done in this department; a band organized, silk National colors purchased and college dues remitted for Seniors who elect to drill as cadet officers.

NEEDS:—

1. College, instead of individual students, should purchase instruments for band.
2. Appropriation for this department should be increased to $200 annually.
3. Battalion colors to go with National Colors.
4. Flagstaff, halyards and flag for armory.
5. Necessary State legislation so that work in Military Department evidenced by diploma of college and recommendation of the Commandant be recognized by the National Guard of New Hampshire, e. g., commission as captain for term (five) years or until removal from State.
6. Provision for limited number of cadet officers to be assigned to staff departments N. H. N. G. during annual encampment at Concord, N. H.
7. An annual camp of at least one week in early fall.
8. A scholarship offered to one member of each company of the National Guard, such student to retain his membership in National Guard while in college.

Respectfully.

WM. E. HUNT,
Captain 22nd U. S. Infantry.
Professor of Military Science and Tactics.

Department of Modern Languages.

I beg leave to submit the following report with regard to the condition and needs of the Modern Language Department.

The total number of students taking French, German, and Spanish is 156. The head of the department has 18 recitations per week, and Mr. Spencer, his assistant, has 9 recitations in French, German and Spanish in addition to 9 recitations in English.

It is advisable to have 4 divisions instead of 2 in Freshman German, for at present we have 43 in one division and 30 in the other.

There is a demand for a fourth year in French and German literature and another year in composition. The head of the department has met this demand in a measure in previous years, but the members in the lower classes are becoming so large, that more assistance will be needed in the immediate future.

I recommend, therefore, that an assistant be employed who will give his full time to this department.

Yours very truly,

RICHARD WHORISKEY,

Professor of Modern Languages.

Department of Drawing and Design.

Since the last biennial report was issued, the Drawing Department has moved from the room on the second floor of Thompson Hall to the first floor of the same building, so that, at present, there is ample room for classes now taking Drawing and Machine Design, and extra room enough to accommodate a considerable increase in the number of students.

The drawing tables and stands used for Freshman Drawing are sufficient in number for classes not larger than the present Freshman class. These should be replaced, however, by 50 substantial tables which should be fitted with drawers for drawing supplies, and bolted to the floor.

The equipment in the Senior Drawing room should be improved also, and increased so as to accommodate 40 students.

The department has at present, 3 cases for drawing boards and student supplies, each with 15 lockers. Three additional cases are greatly needed, one for the Senior and Junior room and two for the Freshman room, all to be fitted for master keys.

The department has a good collection of models for *free hand drawing*, but greatly needs additional models for machine drafting and a horizontal type of engine, cut in section, for valve design.

A catalog case, for holding and filing of trade catalogs and a blue print filing case are also much needed.

Respectfully submitted,

F. W. PUTNAM,

Professor of Drawing and Design.

Department of Botany.

The department has recently increased its equipment by the addition of a few tables and microscopes. Its supply in each of these lines needs to be doubled in order to satisfactorily acommodate the present number of students. It is greatly in need of a

stereopticon for lecture and laboratory purposes. One of its most urgent wants is a small greenhouse in which laboratory material may be grown and kept. It has a satisfactory lecture room but needs more laboratory space.

CHARLES BROOKS,
Professor of Botany.

Department of Electrical Engineering.

I beg to report in regard to the condition and needs of my department.

In the first place, we have a very strong course in Electrical Engineering, one that will compare favorably with some of our best technical institutions, as far as the text books and lecture work are concerned; but we are poorly provided with instruments, machines, and the general equipment, essential for carrying on efficient laboratory work. This branch of an Electrical Engineering course is of very great importance and such a course cannot be completed without it.

Our greatest needs are better facilities, more room, more apparatus and above all a new Engineering Building.

We are now greatly handicapped for want of lecture room space. We are obliged to hold classes in laboratory rooms where there is only small blackboard space and no seating accommodations except ordinary chairs.

The present indications point to the fact that the largest per cent. of students entering this college choose the engineering courses and if the numbers increase each year as they have during the past few years, it will not be long when it will be practically impossible to care for them in my department with present facilities.

I would urge very strongly that steps be taken at the earliest possible moment for the providing of funds necessary to erect a suitable building to meet the urgent requirements of the Engineering Departments.

Respectfully submitted,
C. E. HEWITT,
Professor Electrical Engineering.

Department of Horticulture.

I have the honor to present herewith my first annual report as professor of Horticulture and Forestry. My duties commenced on July 1, and I have, therefore, but a brief account to give of the work of the department from that date to October 1. For

convenience I have divided this report into subheadings as follows: Care of Roads and Grounds; Forestry; Instruction; Needs of the Department.

CARE OF ROADS AND GROUNDS.

The grounds have been kept in good condition throughout the season so far as mowing the grass and ordinary care are concerned. The very dry weather and clouds of dust throughout the months of June and July left the lawns very brown and dry and the trees very dirty in appearance. Later rains improved the condition to such an extent that the campus presented a very handsome appearance throughout the months of August and September.

The condition of the roads is not first-class. The drives leading to Thompson Hall are in need of regravelling and stone gutters should be laid along the sides to prevent washing. All roads have been kept free from weeds. A new crossing was constructed over the B. & M. track on the service drive near the power house.

The largest single piece of work done on the campus this fall was the grading of the grounds about the woman's dormitory, or Smith Hall. This work was completed, so far as present funds will allow, before the opening of college and has been inspected by the Board of Trustees.

No extensive planting was done on the grounds this year. Two flower beds were planted near the greenhouses and near Morrill Hall and next year a third will be planted in front of Smith Hall. All other planting will be confined to shrubs and trees, as it is believed that such plants are more in keeping with the dignity of the buildings and the extent of the grounds, and moreover they are much less costly to maintain.

FORESTRY.

No work has been done in the college forest during the past few months. I found a large quantity of lumber on hand when I took charge of the department. Small quantities have been sold locally from time to time and the sales duly turned in to the business office. It is proposed to dispose of this lumber in bulk to a commercial lumber company late this fall or early this winter, retaining only sufficient to supply the college needs.

INSTRUCTION.

Courses in horticulture are given throughout the four years of the agricultural course. The courses with students enrolled at the present time are as follows:

Principles of Horticulture, for Freshmen in 4 year course, 16 students.

Special in Pomology, for Seniors, 4 students.

Pomology and Viticulture, for Juniors in 4 year course, 4 students.

Landscape Gardening, for Seniors, 2 students.

Special in Floriculture, for Seniors, 1 student.

Special in Forestry (study of native trees) 2 students.

Plant Growth and greenhouses, for 2nd year, 2 year course, 7 students.

Plant Growth and greenhouse for 2nd year, 2 year course, 8 students.

Vegetable Gardening, for 1st year, 2 year course, 15 students.

The total number of hours' instruction given per week by the department at the present time amounts to fifty-four.

Needs of the Department.

Experiment Station Work.

The character of the land now under control of the Horticultural Department is detrimental to good experimental work. The land is too scattered in location, is uneven in quality, and so stony as to need expensive clearing of rocks to fit it for good work. After a careful study of the soil conditions on the college farm, I am, however, convinced that the land allotted to the Horticultural Department so far as it goes, can be made fairly satisfactory for experimental work by the expenditure of a reasonable sum of money for clearing it of rock, manuring it and fencing it. I recommend, therefore, that an appropriation of not less than $600 be made for the purpose of clearing rocks from the orchards and garden soils and for the fencing of the college or Thompson orchard.

It is imperative in the pomological branch of the work of the Horticultural Department that a small fruit plantation be started at the earliest possible date consistent with the proper choice of location and preparation of the soil.

A further matter demanding pressing attention is the construction of a proper packing and storage house for fruits and vegetables. One of the important factors in the business of fruit and vegetable marketing at the present time is cold or cool storage, and it is not only desirable but necessary that the Horticultural Department lead in demonstrating the practicability of cold storage of fruits and vegetables for New Hampshire condition. A second factor of equal importance is the proper packing for market of horticultural products; and a building of inex-

pensive but permanent character combining these two features is an absolute necessity. A building of this character erected in 1901, of which the writer knows all particulars, cost the sum of $3,430.40. The cost of building is somewhat greater now and the sum of $4,000 is asked for to cover all expenses. About $2,000 of this would return to the college for the purchase of lumber, making the actual cash outlay about $2,000 for the work, a very cheap investment and one that will result in a saving of several hundred dollars every year by storage of fruits and vegetables that would otherwise be lost. The head of the Department of Horticulture is willing to undertake to build this storage house from sales from the Forestry Department and to make only judicious cuttings from the college forest in doing so.

Roads and Grounds.

So much could be done to beautify and improve the conditions of the roads and grounds that I am at a loss to state which conditions are in most pressing need of attention. I should, however, recommend two things for immediate action.

First—The construction of cement sidewalks leading to and from the principal buildings, and extending along the main road from a point opposite Nesmith Hall to the inside of the southeast drive leading to the Library. An estimate of the cost of the walks to be laid the first year, amounting to $1,000, has already been submitted for your consideration.

Second—There is immediate need for the planting of a large number of trees. The grounds about Thompson Hall, the Library and Smith Hall are in need of planting. This work should not be delayed. Every year is precious in the growth of a tree. The amount needed for this work is $200.

Maintenance.

The grounds cannot be maintained for less than $1,200 next year. In addition to the ordinary running expenses which we had to meet this year, the needs of this work require the purchase of a two horse farm wagon for transportation of gravel, manures, hay, etc., and also a new horse lawn-mower. Moreover we have the additional care of the grounds at Smith Hall.

Grading.

Neither the grading about Smith Hall nor at the Library has been completed. I am not prepared to say what either will cost. To complete the grading at Smith Hall and make it level with the road in front will cost $1,400. I recommend however, that the ground there be left nearly in its present con-

dition but that enough money be appropriated to finish the grading- at the back and sides of the building, to properly drain the front lawn, and to smooth off the boulders which are in the central part of the lawn. The ledges at the sides can be used to advantage as landscape features by judicious planting. The cost of completing the grading in this manner will be in the neighborhood of $450.

Changes and additions to staff.

Two changes of immediate importance are necessary.

Mr. Lumsden, the general foreman, is too heavily burdened with conflicting duties to perform efficient service. I wish him to confine himself strictly to the work of the greenhouses, outdoor floriculture, and a general supervision of the roads and grounds. It will be necessary then to appoint a foreman who will have immediate and personal supervision of the labor, the sales of garden truck, lumber, etc., at $60 per month. *This change is imperative.* More than the foreman's salary will be saved in added efficiency of the labor force as a result of personal supervision and undivided attention.

An assistant in Vegetable Gardening should be added to the staff of the department as early as possible next spring. This assistant will give the lectures on this subject and take charge of the work in the vegetable gardens, the principal line of work as indicated being investigations on the breeding of tomatoes and squashes.

I further recommend that a first class instructor in forestry be added to the staff either of this department or as head of a separate department. There are at this time at least four students enrolled who purpose taking full courses in forestry and with the present equipment of the teaching staff it is impossible to outline complete courses in this subject and inquiries for such a course are numerous. The importance of this action on the part of the college needs no further statement. Forestry in New Hampshire is a matter of vital importance. The call comes from the people and should be heeded at once if the college is to perform the most efficient service for the state.

It is with great pleasure that I speak of the cheerful and efficient service rendered by Mr. W. H. Wicks, the newly appointed assistant in Horticulture and by Mr. David Lumsden, foreman of gardens and greenhouse. Both men have given unselfish attention to their work and have done all in their power to advance the interests of the department.

I would call attention especially to Mr. Wicks' work in con-

nection with the exhibits made by this department at the State Fair and at the fair at Rochester. The demonstration in apple packing and pruning made at these fairs reached many of the farmers in a personal way. Mr. Wicks' work was also responsible for the success which attended the apple packing experiments in the town of Deerfield. Mr. Wicks gives the instruction in all branches of Pomology in the college courses.

Mr. Lumsden, in addition to his duties as foreman and florist, has found time to grow vegetables in two of the greenhouses, make many self and cross-fertilizations on cucumbers, musk-melons, and tomatoes, and to conduct the class work in floriculture and landscape gardening.

B. S. PICKETT,

Professor of Horticulture and Forestry.

Department of English and Philosophy.

ENGLISH.

The college has recognized the great need of training its students in the writing of forceful, correct English. The emphasis that has been placed upon practice has been justified by the results. There has been a gradual improvement in the writing of the students, and the work of the first year has been made more interesting. The courses offered are now thoroughly organized and closely related. Of additional advanced courses there is great need. The enrichment of the General Course especially demands an increase in the number of such English courses, but, with the present teaching force, such an increase is impossible.

PHILOSOPHY.

The value of the study of philosophy in a scientific institution has often been emphasized by leading educators. At New Hampshire College the courses in philosophy have always been popular, even though the demands of professional preparation have made it impossible for some students to elect the work in philosophy in which they were naturally interested. The demand for courses in pedagogy, however, has forced the department to decrease those offered in philosophy, and, at the present time, only two purely philosophic courses are given during the college year.

The work in pedagogy has grown in importance until its value to the student who plans to teach is no longer debated. The courses in pedagogy attempt to help the student enter upon his teaching in the high school or college with facility and sympathetic understanding.

At present the instructor in pedagogy has to divide his time between the work of this department and English. The proper development of these courses demands the entire time of one instructor.

E. R. GROVES,
Professor of English and Philosophy.

Mechanical Engineering Department.

I have the honor to report as follows in regard to the condition and needs of the Mechanical Engineering Department.

The Department of Mechanical Engineering is responsible for the larger part of the professional instruction given to all students in Mechanical and Electrical Engineering, as well as for some of the instruction given to Chemical and Agricultural students. Since fully 45 per cent. of our student body are studying Mechanical and Electrical Engineering, it follows that the usefulness of this college to the State of New Hampshire depends in a very large measure on the degree of thoroughness and excellence of the instruction imparted by the Mechanical Engineering Department.

The State of New Hampshire is essentially a manufacturing community. Her continued prosperity depends more upon the wise and efficient direction of the efforts of her population in manufacturing lines, than upon any other factor. The education of some of her young men as engineers is therefore essential to the welfare of the state, for otherwise her industries will lack for proper direction, and suffer as a consequence.

It therefore follows that it is the duty of the state not only to provide the means for obtaining such education, but to foster such schools as carefully, and deal with them as generously as any other schools forming a part of her educational system.

The value of these men to the industries of the state will depend upon the excellence of the professional training which we are able to give them. In the case of an engineering school, the excellence attained depends first upon a right order of studies and a proper apportionment of time among the several subjects, second upon good teaching of these subjects, and third upon proper and adequate class room and laboratory facilities.

Professor Hewitt, the head of the Electrical Engineering Department, and myself are preparing a schedule of studies for the Mechanical Engineering and Electrical Engineering courses, introducing some changes both in the subject matter and in the order of our present courses, with the object in mind of improving in the highest degree possible by that means, the

efficiency of the work. These changes, if made, cannot be fully brought about before the year 1912-13, but it will be possible by this means alone to make steady improvements in our work in the meanwhile.

The grade of teaching done will depend not only upon the professional and teaching ability of the instructor concerned, but also upon the amount of work which he has to do. The greater the number of subjects he is called upon to teach, the less the time he can devote to the preparation of his work, and the poorer will be the quality of his instruction. The amount of instruction given by the Mechanical Engineering Department is such that it is impossible to devote adequate time to the preparation of the work, and the instruction is therefore not as efficient as it should be. This defect can be remedied by more assistance, and until it is so remedied, our work must suffer.

In the matter of class room and laboratory facilities, the college is very deficient. Our mechanical laboratory is poorly equipped, and lacks instruments and apparatus of all kinds. Not only do we need more apparatus, but we need more room for the apparatus we have. We also need a mechanician who will devote his time to the building and repair of laboratory apparatus. Such a man is a part of the regular staff of every first-class technical school, while many of the larger schools have four or five such men.

Our shops, like our laboratory, are lacking in equipment, and are very much over crowded. Many of our tools are so poor as to be useless for purposes of instruction. In many of our sections, we have more men working than we have tools upon which they can work, and if new tools were secured, there would not be floor space for them. Both our foundry and blacksmith shop are lacking in equipment necessary to make their work of real value to Engineering Students, the foundry more especially, and there is not sufficient room to add this equipment, if it were built or purchased.

In every sub-division of the Mechanical Engineering Department, we feel the hampering effects of this lack of room and equipment. We need a reading room and a place for a department library. Our locker rooms are inadequate. The same is true of our tool rooms. We have no proper lecture or demonstration rooms, and our only recitation room is at a distance from our offices and apparatus. Our difficulties can only be met by the erection of a suitable engineering building.

In summarizing, I would say, that considering our facilites,

our condition is good, and will be bettered as fast as is possible. Our needs are, first, a new engineering building, second, more and better shop and laboratory equipment, and third, additional assistance for our instructing staff. Unless we get these things we must be content to be a second class institution of questionable utility to the state.

In addition to his duties as Professor of Mechanical Engineering, the writer also has the supervision of the Power and Service Department, and of the Buildings and Repairs Department. There are certain matters in connection with the work of these departments to which I wish to call your attention.

The first of these is the necessity of supplying potable water to the different college buildings. Our present water supply while excellent for the use of our boiler plant, is unfit to drink, and often of such disgusting odor as to make its use even for sanitary purposes, unpleasant. An adequate supply can be obtained more cheaply from drilled wells than in any other way. I am unable to state at present the number and cost of the wells necessary to produce the required supply, but am giving the matter my earnest attention.

The second matter is the necessity of outside painting for several of the buildings, the wood work being in some cases unprotected from the elements. The cost of this work I am informed would be about $500.

A third matter is in connection with the need of the college for an electric generator of larger capacity. The present generator is likely to burn out on account of the overload at any time. A 50 K. W. unit, in the form of a steam turbine driven alternator could be installed at a cost of about $2,500. This unit should be so connected that the exhaust steam could be used for heating the college buildings, instead of live steam directly from the boilers, thus enabling us to furnish our light and power without cost, at such times as we need steam for heating.

At other times, it is the writer's opinion that it would be cheaper to buy our power, rather than run the power plant. This is especially true, since the demand for power during the months that we are not heating is comparatively light, and the cost per K. W. of producing the power is relatively higher. Such an arrangement would be of great advantage to some of the other departments which are now handicapped through the lack of a continuous source of power. The cost of the apparatus necessary to utilize electric instead of steam power, would be about $2,000 to $2,500. The saving which could be affected by

these changes would be at least $750 per year, an amount sufficient to warrant the making of them, without any question.

FORREST E. CARDULLO,
Professor of Mechanical Engineering.

Department of Dairying.

I submit herewith the following report on the present condition and needs of the Dairy Department.

As the College Creamery was built before the subject of dairying was taught in a systematic way in colleges and at a time when the number of students taking dairy work was comparatively few, it was planned and constructed more as a commercial buttermaking plant than a place suitable for giving instruction to the dairy student. With the constant increase in the agricultural students the building as far as room and arrangement are concerned has been for several years entirely inadequate to fulfill the needs of the Dairy Department.

Aside from the inadequacy regarding room and equipment, the construction and the present condition of the building from a sanitary standpoint does not measure up to the requirements of the present day. The public health authorities and the dairy educators have, during recent years, given increased attention to the relation of milk and other dairy products to public health. The ideals of cleanliness and sanitation have greatly changed. Due to the continual use of water day after day for years the frame work of the building and the floors have gradually softened and are now rapidly decaying not only making the building very faulty from a sanitary standpoint but the safety of the building is also at present a point for serious consideration.

Considering the unsanitary condition of the building and its inadequacy for giving efficient instruction to the present number of students, the greatest need of the Dairy Department is a new Dairy Building. The need has been felt for several years, but each year it becomes more urgent.

At present there is no dairy class room, the classes being conducted in the agricultural building wherever room is available. Additional instructors have been added to the teaching force in the Horticultural, Animal Husbandry and Agronomy Departments. New courses of study have been introduced in these departments and it has been exceedingly difficult of late for the classes in Dairying to obtain a class room for lectures and recitations.

The topography of the country, the climate, the fact that a large portion of the soil is depleted of its fertility and the steady

increasing demand for dairy products, will always make dairying preeminent in New Hampshire agriculture. The dairy industry in the state is quite diversified. It includes the production and handling of milk for city supply, factory and farm buttermaking, factory and farm cheese making, the condensing of milk and the making of ice cream. In planning and erecting a dairy building the one thought never to be lost sight of is to build to suit the needs of the dairy industry in New Hampshire and the needs of the Agricultural College.

To fill these needs such a building should contain suitable laboratories equipped for teaching the following subjects: Handling of milk for city supply; farm buttermaking; cheese making, milk testing and milk inspection; ice cream making, dairy bacteriology and creamery buttermaking. In addition, the building should contain offices, class rooms, and a reading room.

The Federal Government appropriates over $25,000 this year for experimental and research work in Agriculture. The dairy industry of New Hampshire warrants that a fair share of this be used for work along dairy lines. To make this work efficient the building should be equipped with a suitable cold storage system, for to be able to perfectly control temperature is one of the very essential factors in experimental work whether it be directed along the lines of the manufacture of cheese and butter or along bacteriological lines. Dairy bacteriology and dairy chemistry are becoming more and more important in experimental and research work and without suitable room and equipment for such work the building would not be complete.

FRED RASMUSSEN,
Associate Professor of Dairying.

Department of Animal Husbandry.

The Department of Animal Husbandry is better equipped in some respects for teaching its subjects than a year ago. Within the past few months the volumes of the following Herd Books and Flock Books have been brought up to date:

1. American Short-Horn Herd Book.
2. American South Down Record.
3. Herd Register of the American Jersey Cattle Club.
4. Holstein-Fresian Herd Book.
5. American Berkshire Record.
6. Herd Register of the American Guernsey Cattle Club.
7. Continental Dorset Club Record.

In the class room additions have been made in the way of

maps, photographs and tables which greatly facilitate the work.

The condition of the college herd is worthy of note from the standpoint of increase and future growth. At the present time the milking herd consists of thirteen aged cows and two 3 year old heifers. By January 1, 1909 the milking herd will number seventeen head. During 1909, five heifers will freshen bringing the number to twenty-two. These heifers will take the place of some of the older cows which will necessarily be culled out during the next two years. In order to keep the numbers of the herd up to the point where it ought to be and to have representative types for judging work, six animals of the following breeds ought to be added:

2 Holsteins.

3 Guernseys.

1 Ayrshire.

The present herd of hogs, while about thirty-five in number of common breeding, have practically no winter quarters. Before a representative herd of hogs can be maintained a suitable piggery must be constructed.

W. H. PEW,
Associate Professor of Animal Husbandry.

Library.

I beg to submit the following statement of the present condition of the library.

The library of the college contains about fourteen thousand bound volumes and over seven thousand pamphlets. The books have been selected with reference to the instruction given in the college and include, therefore, the more technical and specialized working collections for the different scientific departments as well as a reference library of broader scope covering economic science and literature.

The new library building gives shelf room for at least sixty-five thousand volumes; and its reading room is well supplied with the best scientific and general periodicals. By the arrangement which brings the town and college libraries into the same building, the town collection of nine thousand well chosen volumes is easily available for the use of the college.

MABEL HODGKINS,
Librarian.

PRESIDENT'S GOVERNMENT REPORT.

Name of Institution, NEW HAMPSHIRE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS.

Post-office, DURHAM; *State*, NEW HAMPSHIRE.

Report of the President of said institution to the Secretary of the Interior and the Secretary of Agriculture, as required by act of Congress of August 30, 1890, in aid of Colleges of Agriculture and the Mechanic Arts.

I. Condition and Progress of the Institution for the Year Ending, June 30, 1907, Especially—

(1) Changes in courses or methods of instruction if of sufficient importance to warrant mention, and (2) purpose, structural character, and cost of new buildings or additions to buildings.

The new library building was dedicated June 3rd, 1907. It was erected at a cost of $32,888 of which amount $20,000 was furnished by Andrew Carnegie and $12,888 by the Hamilton Smith estate. The building is of red pressed brick with Indiana limestone trimmings and slate roof. It has ample reading and reference rooms, also seminar and study rooms and a large historical collection room besides librarian's office, catalog room, and a three-story stack room with a capacity of 60,000 volumes. In this building will be consolidated the libraries of the college, the Durham Library Association and the Durham Public Library. The consolidated library will also receive the benefit of the invested funds of the Durham Library Association amounting to about $11,000. The library will be maintained by the college for the free use of faculty, students, members of the Durham Library Association and citizens of Durham.

II. Value of Additions to Equipment During the Year Ending June 30, 1907.

(*b*)	Buildings	$32,000.00
(*c*)	Library	2,000.00
(*d*)	Apparatus	2,000.00
(*e*)	Machinery	215.00
(*f*)	Live Stock	837.64
	Total	$37,052.64

III. Receipts for and During the Year Ending June 30, 1907.

1. State aid:	
(c) Appropriation for current expenses	$13,000.00
2. Federal aid:	
(a) Income from land grant, act of July 2, 1862	4,800.00
(c) Additional endowment act of August 30, 1890	25,000.00
3. Income from endowment other than Federal or State grants	3,252.00
4. Fees and all other sources:	
(a) Tuition fees	3,603.50
(b) Incidental fees	2,012.42
(c) Miscellaneous receipts	36,760.79
(d) Andrew Carnegie—library	20,000.00
(e) Hamilton Smith Estate—library	12,888.00
5. Total	$121,316.71
6. Federal appropriation for experiment stations	22,000.00

IV. Property, Year Ending June 30, 1907.

Value of buildings, $268,000; of farm and grounds, $20,500; of apparatus, $28,000; of machinery, $6,800; of library, $15,000; of live stock, $4,500; of other equipment, $16,000.

Total number of acres in farm and grounds, 343; acres under cultivation, 100.

Amount of land-grant fund of July 2, 1862, $80,000; amount of other endowment funds, $70,000.

Number of bound volumes in library, June 30, 1907, 13,476; pamphlets, 3,800..

V. Professors and Instructors During the Year Ending June 30, 1907.

	Male.
1. College of Agriculture and Mechanic Arts:	
(b) Collegiate and special classes	26
(c) Total, counting none twice	26
2. Number of staff of experiment station	11

VI. Students During the Year Ending June 30, 1907.

1. College of Agriculture and Mechanic Arts:

	Male.	Female.
(*b*) Collegiate classes (including special students in college classes)	154	11
(*c*) Post-graduate courses	1	
(*d*) Short or special Courses........	39	3
Total, counting none twice...........	194	14

3. Number of college students in regular four year agricultural course, 13; mechanical engineering course, 23; electrical engineering course, 24; chemical engineering course, 13; general science course 13; 70 freshmen unclassified.

4. Number of students in short and special courses in agriculture, 31; dairying, 13.

6. Number of students in military drill, 170.

7. How many students graduated from undergraduate college courses during year ending June 30, 1907? Men, 12; women, 2. Ten from two year course in agriculture.

8. Average age of students graduated from undergraduate college courses during year ending June 30, 1907, 22½.

9. What degrees and how many of each kind were conferred during year ending June 30, 1907? On men, 12 B. S., 1 M. S. On women, 2 B. S.

10. What and how many honorary degrees were conferred during year ending June 30, 1907? None.

(Signed) W. D. GIBBS, *President.*

Date, August 7, 1907.

PRESIDENT'S GOVERNMENT REPORT.

Name of Institution, NEW HAMPSHIRE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS.

Post-office, DURHAM; *State*, NEW HAMPSHIRE.

Report of the President of said institution to the Secretary of the Interior and the Secretary of Agriculture, as required by act of Congress of August 30, 1890, in aid of Colleges of Agriculture and the Mechanic Arts.

I. Condition and Progress of the Institution for the Year Ending June 30, 1908, Especially—

(1) Changes in courses or methods of instruction if of sufficient importance to warrant mention, and (2) purpose, structural

character, and cost of new buildings or additions to buildings. (1) The three term plan of instruction changed to the two semester plan. (2) A new building for women—Smith Hall—has been erected at a cost, including equipment, of $28,500. The structure is brick, three stories and basement, slate roof, and will accommodate 40 girls. The funds were procured as follows:—

$16,000 Mrs. Sherly Onderdonk, Durham, N. H.
10,000 State appropriation.
2,500 State appropriation.

Building to be occupied Sept., 1908.

II. Value of Additions to Equipment During the Year Ending June 30, 1908.

(*a*) Permanent endowment	$300.00
(*b*) Buildings, Smith Hall for women (almost completed)	28,500.00
(*c*) Library, 11,061 vol. pamphlets	10,187.00
(*d*) Apparatus	2,000.00
(*e*) Machinery	450.00
(*f*) Live stock (not including experiment station purchases)	218.00
(*g*) Miscellaneous	500.00
Total	$42,155.00

III. Receipts for and During the Year Ending June 30, 1908.

1. State aid:	
(*c*) Appropriation for current expenses	$13,000.00
(*e*) Appropriations for buildings or for other special purposes	34,000.00
2. Federal aid:	
(*a*) Income from land grant, act of July 2, 1862 (State Bonds)	4,800.00
(*c*) Additional endowment acts of August 30, 1890, and March 4, 1907	30,000.00
3. Income from endowment other than Federal or State grants	3,292.00
4. Fees and all other sources:	
(*a*) Tuition fees	3,696.00
(*b*) Incidental fees	1,994.46
(*c*) Miscellaneous receipts	64,665.04
5. Total	$155,447.50
6. Federal appropriation for experiment stations	24,000.00

IV. Property, Year Ending June 30, 1908.

Value of buildings, $332,000; of farm and grounds, $30,000; of apparatus, $30,000; of machinery, $10,000; of library, $25,000; of live stock, $4,374; of other equipment, $20,000.

Total number of acres in farm and grounds, 345; acres under cultivation, 100.

Amount of land-grant fund of July 2, 1862, $80,000; amount of other endowment funds, $70,000.

Number of bound volumes in library, June 30, 1908, 23,563; pamphlets, 4,500.

V. Professors and Instructors During the Year Ending June 30, 1908.

1. College of Agriculture and Mechanic Arts:	
(*b*) Collegiate and special classes	31
(c) Total, counting none twice	31
2. Number in all other departments (*avoid duplication*)	31
3. Number of staff of experiment station	11

VI. Students During the Year Ending June 30, 1908.

1. College of Agriculture and Mechanic Arts:

	Male.	Female.
(*b*) Collegiate classes (including special students in college courses)	166	15
(d) Short or special courses	22	
Total, counting none twice	188	15

†3. Number of college students in regular four year agricultural course, 50; mechanical engineering course, 17; electrical engineering course, 18; chemical engineering course, 19; and *general engineering course (including engineering students not yet classified by courses), 28; general science course, 11.

4. Number of students in short and special courses in agriture, 15; dairying, 7.

7. Number of students in military drill, 154.

8. How many students graduated from undergraduate college courses during year ending June 30, 1908? Men, 27; women, 3.

9. Average age of students graduated from undergraduate college courses during year ending June 30, 1908, about 22½.

*Sophomore engineers unclassified.
†All freshmen unclassified as to courses.

10. What degrees and how many of each kind were conferred during year ending June 30, 1908? On men, 27 B. S. On women, 3 B. S.

11. What and how many honorary degrees were conferred during year ending June 30, 1908? None.

(Signed) W. D. GIBBS, *President.*

Date, Sept. 1, 1908.

TREASURER'S GOVERNMENT REPORT.

Name of Institution, NEW HAMPSHIRE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS.

Post-office, DURHAM; *State,* NEW HAMPSHIRE.

Report of treasurer of said institution to the Secretary of Agriculture and the Secretary of the Interior, of amount received under act of Congress of August 30, 1890, in aid of Colleges of Agriculture and the Mechanic Arts, and of the disbursements thereof, to and including June 30, 1907.

Receipts.

Received from the United States government.......	$25,000.00

Disbursements.

Disbursed for instruction and facilities:	
In agriculture, as per schedule A....................	$4,381.26
In mechanic arts, as per schedule B.................	8,304.49
In English language, as per schedule C.............	1,126.02
In mathematical science, as per schedule D.........	2,158.42
In natural or physical science, as per schedule E...	7,517.15
In economic science, as per schedule F.............	1,512.66
Total	$25,000.00

I hereby certify that the above account is correct and true, and, together with the schedules hereunto attached, truly represents the details of expenditures for the period and by the institution named; that said expenditures were applied only to instruction in agriculture, the mechanic arts, the English language and the various branches of mathematical, physical, natural, and economic science, with special reference to their applications in the industries of life, and to the facilities for such instruction,

and that no part of these funds was expended for the erection, preservation, or repair of any building or buildings.

(Signed)

WALTER M. PARKER, *Treasurer.*

SCHEDULE A.—*Disbursements for instruction in Agriculture, and for facilities for such instruction, during the year ended June 30, 1907.*

I. For instruction, viz:

For the salaries of (1) Professor of Agriculture, \$800.00; (2) Professor of Agricultural Chemistry, \$400.00; (3) Assistant Professor of Agriculture, \$550.01; (4) Professor of Horticulture and Forestry \$761.91; (5) Instructors in Horticulture, \$178.37; (6) Instructors in Dairying, \$522.80	\$3,213.09
II. For facilities, as follows:	
For apparatus, stock and materials	1,096.33
For text-books and reference books	71.84
Total	\$4,381.26

SCHEDULE B.—*Disbursements for instruction in Mechanic Arts and for facilities for such instruction, during the year ended June 30, 1907.*

I. For instruction, viz.:

For the salaries of (1) Professor of Mechanical Engineering, \$2,000.00; (2) Assistant Professor of Mechanical Engineering, \$925.50; (3) Instructors in Machine work, \$1,059.99; (4) Professor of Electrical Engineering, \$900.00; (5) Instructor in Electrical Engineering, \$459.96; (6) Associate Professor of Drawing and Design, \$1,299.99	\$6,645.44
II. For facilities, as follows:	
For apparatus, stock and materials	1,495.10
For text-books and reference books	163.95
Total	\$8,304.49

SCHEDULE C.—*Disbursements for instruction in English Language, and for facilities for such instruction, during the year ended June 30, 1907.*

I. For instruction, viz:

For salaries of Instructors in English Language	$918.36
II. For facilities, as follows:	
For text-books and reference books	207.66
Total	$1,126.02

SCHEDULE D.—*Disbursements for instruction in Mathematical Science, and for facilities for such instruction, during the year ended June 30, 1907.*

I. For instruction, viz:

For the salary of the Professor of Mathematics	$2,131.27
II. For facilities, as follows:	
For apparatus, stock and materials	27.15
Total	$2,158.42

SCHEDULE E.—*Disbursements for instruction in Natural or Physical Science and for facilities for such instruction during the year ended June 30, 1907.*

I. For instruction, viz:

For the salaries of (1) Professor of Chemistry, $2,416.62; (2) Instructors in Chemistry, $1,200.00; (3) Professor of Physics, $900.00; (4) Instructors in Physics, $459.96; (5) Associate Professor of Botany, $300.00; (6) Professor of Zoology and Entomology, $800.00; (7) Assistant Professor of Zoology and Entomology, $100.00	$6,176.58
II. For facilities, as follows:	
For apparatus, stock and materials	366.39
For text-books and reference books	974.18
Total	$7,517.15

SCHEDULE F.—*Disbursements for instruction in Economic Science, and for facilities for such instruction, during the year ended June 30, 1907.*

I. For instruction, viz:

For Professor of Economic Science	$1,400.00
II. For facilities, as follows:	
For text-books and reference books	112.66
Total	$1,512.66

TREASURER'S GOVERNMENT REPORT.

Name of Institution, New Hampshire College of Agriculture and the Mechanic Arts.

Post-office, Durham, *State*, New Hampshire.

Report of treasurer of said institution to the Secretary of the interior and the Secretary of Agriculture, of amount received under act of Congress of August 30, 1890, and March 4, 1907, in aid of Colleges of Agriculture and the Mechanic Arts, and of the disbursements thereof, to and including June 30, 1908.

Receipts.

Received from the United States government........	$30,000.00

Disbursements.

Disbursed for instruction and facilities:

In agriculture, as per schedule A....................	$4,482.78
In mechanic arts, as per schedule B.................	10,039.71
In English language, as per schedule C..............	1,534.81
In mathematical science, as per schedule D..........	2,544.61
In natural or physical science, as per schedule E.....	9,931.23
In economic science, as per schedule F..............	1,466.86
Total expended during year	$30,000.00

I hereby certify that the above account is correct and true, and together with the schedules hereunto attached, truly represents the details of expenditures for the period and by the institution named; that said expenditures were applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their applications in the industries of life, to the special preparation of instructors for teaching the elements of agriculture and the mechanic arts, and to the facilities for such instruction; and that no part of these funds were expended for the erection, preservation, or repair of any building or buildings.

(Signed) WALTER M. PARKER, *Treasurer.*

SCHEDULE A.—*Disbursements for instruction in Agriculture, and for facilities for such instruction, during the year ended June 30, 1908.*

I. For instruction, viz.:

For the salaries of (1) Professor of Agricultural Chemistry, $400.00; (2) Professor of Agriculture, $983.38; (3) Professor of Horticulture, $1,000.00; (4) Instructors in Horticulture, $153.88; (5) Assistant Professor of Animal Husbandry, $600.00; (6) Associate Professor of Dairying, $625.00..........	$3,762.26
II. For facilities, as follows:	
For apparatus, stock, and materials.................	603.84
For text-books and reference books.................	116.68
Total	$4,482.78

SCHEDULE B.—*Disbursements for instruction in Mechanic Arts, and for facilities for such instruction, during the year ended June 30, 1908.*

I. For instruction, viz.:

For the salaries of (1) Professor of Mechanical Engineering, $2,000.00; (2) Professor of Drawing and Design, $1,600.00; (3) Instructor of Drawing, $666.60; (4) Instructors in Machine Work, $1,045.00; (5) Instructor in Wood Work, $600.00; (6) Professor of Electrical Engineering, $983.30; (7) Assistant Professor of Electrical Engineering, $625.00; (8) Assistant in Electrical Engineering, $500.00	$8,019.90
II. For facilities, as follows:	
For apparatus, machinery, stock and material	1,869.45
For text-books and reference books.................	150.36
Total	$10,039.71

SCHEDULE C.—*Disbursements for instruction in English Language, and for facilities for such instruction, during the year ended June 30, 1908.*

I. For instruction, viz.:

For the salaries of (1) Associate Professor of English, $1,066.61; (2) Instructor in English, $312.50	$1,379.11
II. For facilities, as follows:	
For text-books and reference books.................	155.70
Total	$1,534.81

SCHEDULE D. — *Disbursements for instruction in Mathematical Science, and for facilities for such instruction, during the year ended June 30, 1908.*

I. For instruction, viz.:	
For the salaries of (1) Professor of Mathematics, $2,000.00; (2) Instructors in Mathematics, $522.50	$2,522.50
II. For facilities, as follows:	
For apparatus, stock, and materials................	12.61
For text-books and reference books..................	9.50
Total	$2,544.61

SCHEDULE E.—*Disbursements for instruction in Natural and Physical Science, and for facilities for such instruction, during the year ended June 30, 1908.*

I. For instruction, viz.:	
For the salaries of (1) Professor of Chemistry, $2,500.00; (2) Assistant Professor of Chemistry, $1,200.00; (3) Instructor in Chemistry, $833.30; (4) Professor of Physics, $983.30; (5) Assistant Professor of Physics, $625.00; (6) Associate Professor of Botany, $728.78; (7) Professor of Zoology and Entomology, $800.04; (8) Instructors in Entomology, $973.73	$8,644.15
II. For facilities, as follows:	
For apparatus, stock and materials..................	955.79
For text-books and reference books.................	331.29
Total	$9,931.23

SCHEDULE F.—*Disbursements for instruction in Economic Science, and for facilities for such instruction, during the year ended June 30, 1908.*

I. For instruction, viz.:	
For Professor of Economic Science..................	$1,400.00
II. For facilities, as follows:	
For text-books and reference books..................	66.86
Total	$1,466.86

COLLEGE TREASURER'S REPORT TO TRUSTEES

To the President and Trustees of the New Hampshire College of Agriculture and the Mechanic Arts:—Your Treasurer respectfully submits his report for the period from July 1, 1906 to July 1, 1907.

WALTER M. PARKER, Treasurer, in account with New Hampshire College of Agriculture and the Mechanic Arts.

Income Conant Fund	$2,845.00
Interest State Bonds	4,800.00
State Appropriation	13,000.00
Government Appropriation	52,000.00
W. D. Gibbs, President	26,265.23
L. Thompson, Treas. Real Estate Com	215.30
Income Pillsbury Fund	7.00
Adams Fund (To reimburse College for payments on account this Fund to June 30, 1906)	2,119.79
Borrowed	13,469.49
Income Hamilton Smith Fund	400.00
Library Fund (To reimburse College for payments made on account Library)	306.90
	$115,428.71
Schedules	$102,126.26
Notes	12,729.56
Interest on Notes	425.38
Cash on hand, July 1, 1907	147.51
	$115,428.71

LIBRARY FUND.

Andrew Carnegie	$20,000.00
Hamilton Smith Estate	12,888.00
	$32,888.00
Schedules	$31,638.13
Cash on hand July 1, 1907	1,249.87
	$32,888.00

COLLEGE TREASURER'S REPORT TO TRUSTEES

To the President and Trustees of the New Hampshire College of Agriculture and the Mechanic Arts:—Your Treasurer respectfully submits his report for the period from July 1, 1907 to July 2, 1908.

WALTER M. PARKER, Treasurer, in account with New Hampshire College of Agriculture and the Mechanic Arts.

Income Conant Fund	$2,805.00
Interest State Bonds	4,800.00
State Appropriation	47,000.00
Government Appropriation	54,000.00
W. D. Gibbs, President	23,571.29
L. Thompson, Treas. Real Estate Com.	106.13
Income Pillsbury Fund	7.00
Conant Fund Hathaway Loan	1,600.00
Interest Hamilton Smith Fund	400.00
Interest Smythe fund	80.00
Borrowed	28,930.57
Cash Balance, July 1, 1907	147.51
	$163,447.50
Schedules	$129,147.03
Notes	29,302.57
Interest on Notes	203.22
Principal Hathaway Loan transfer to Man. Sv. Bk. account No. 84,042	1,600.00
Cash on hand July 2, 1908	3,194.68
	$163,447.50

LIBRARY FUND.

Cash Balance, July 1, 1907	$1,249.87
	$1,249.87
Schedules	$1,190.07
Cash on hand July 2, 1908	59.80
	$1,249.87

MRS. SHERLY ONDERDONK FUND.

Received from Smith & Perkins....................	$16,000.00
	$16,000.00
Schedules	$3,820.00
Cash on hand July 2, 1908..........................	12,180.00
	$16,000.00

Annual financial reports for each year ending June 30 are required of the College by the United States Government. Biennial reports to the Legislature for period ending August 31, are now required by the State. Since it is hardly practical to close the financial accounts twice within two months and since none of the expenditures during July and August of the present year are from state funds, it has been deemed advisable to render a financial statement to July 1 as required by the United States Government and other reports to Sept. 1 as required by the State.

NOTE INDEBTEDNESS AND FUND STATEMENT, JUNE 30, 1907.

PREPARED BY C. H. PETTEE, AUDITOR.

Note Indebtedness.

OUTSTANDING NOTES.

Notes outstanding July 1, 1906	$17,729.56	
Manchester National Bank, note dated Dec. 28, 1906....	3,158.63	
Manchester Savings Bank, note dated March 1, 1907........	3,500.00	
Manchester Savings Bank, note dated March 28, 1907.......	6,810.86	
		$31,199.05

*NOTES PAID.

Manchester Savings Bank, note dated May 31, 1906.........	$6,000.00	
Manchester National Bank, note dated June 29, 1906...	6,229.56	
Manchester National Bank, note dated April 28, 1906...	500.00	
		$12,729.56
Total Note Indebtedness..		$18,469.49

Fund Statement.

CONANT FUND.

Receipts	$2,845.00
Expenditures	2,845.00

LAND GRANT.

Receipts		$4,800.00
Pres. and Sec'y: Salaries..	$3,394.90	
Modern Language: Inst....	1,400.00	
Library: Books	5.10	4,800.00

GENERAL AND MISCELLANEOUS INCOME (EXP. STA.) FUND.

Receipts—		
Cash on hand, July 1, 1906 (General)	$678.73	
State Appropriation	13,000.00	
W. D. Gibbs, President.....	26,265.23	
Lucien Thompson, Treasurer Real Estate Committee...	215.30	
Misc. Inc.: Exp. Station....	2,476.53	
	$42,635.79	
Expenditures	42,514.53	
Cash on hand July 1, 1907....		$121.26

*Several hundred dollars in interest have been saved to the State, during the past year, by using current funds early in the year to pay old indebtedness and by reborrowing later as the money was needed. For details see Treasurer's report.

ADAMS FUND.

Receipts 1906 (See Treasurer's Report for 1906)		$5,000.00
Expenditures	$2,880.21	
	2,119.79	5,000.00
Receipts 1907		$7,000.00
Expenditures		7,000.00

HATCH FUND.

Receipts	$15,000.00
Expenditures	15,000.00

MORRILL FUND.

Receipts		$25,000.00
Expenditures—		
Agr. Sci. Dept..............	$2,292.54	
Farm Dept.	364.00	
Dairy Dept.	746.54	
Horticultural Dept.	978.18	
Mech. Eng. Dept............	5,042.42	
Elect. Eng. Dept............	1,923.21	
Drawing Dept.	1,338.86	
Eng. Lang. Dept............	1,126.02	
Math. Sci. Dept.............	2,158.42	
Chem. Dept.	4,472.53	
Phys. Sci. Dept.............	1,451.36	
Bot. and Bact. Dept.........	452.60	
Zoological Dept.	1,140.66	
Econ. Sci. Dept.............	1,512.66	
		$25,000.00

ROSECRANS W. PILLSBURY FUND.

Receipts	$7.00	
Cash on hand July 1, 1906....	19.25	
Cash on hand July 1, 1907....		$26.25

HAMILTON SMITH FUND.

Receipts	$400.00
Expenditures	400.00

NEW LIBRARY FUND.

Receipts	$32,888.00	
Expenditures	31,638.13	
Cash on hand July 1, 1907....		$1,249.87

NOTE INDEBTEDNESS AND FUND STATEMENT, JULY 2, 1908.

PREPARED BY C. H. PETTEE, AUDITOR.

Note Indebtedness.

OUTSTANDING NOTES.

Manchester National Bank, date June 2, 1904..........	$5,000.00	
Manchester Savings Bank, date Dec. 28, 1906	3,158.63	
Manchester Savings Bank, date Mar. 1, 1907................	3,500.00	
Manchester Savings Bank, date Mar. 28, 1907	6,810.86	
		$18,469.49

NEW NOTES.

Manchester National Bank, date Aug. 29, 1907..........	$1,179.45	
Manchester National Bank, date Mar. 2, 1908...........	1,021.93	
Manchester National Bank, date Mar. 31, 1908..........	6,331.70	
Manchester National Bank, date April 3, 1908...........	2,300.00	
Manchester National Bank, date May 1, 1908............	1,556.95	
Manchester National Bank, date June 1, 1908...........	7,101.46	
Manchester National Bank, date June 30, 1908..........	9,439.08	
		$28,930.57

*NOTES PAID.

July 9, 1907. All notes unpaid on July 1, 1907........	$18,469.49	
Sept. 9, 1907	1,179.45	
Apr. 3, 1908	2,300.00	
Apr. 9, 1908	1,021.93	
Apr. 9, 1908	6,331.70	
		$29,302.57

NOTES UNPAID JULY 2, 1908.

Manchester National Bank....	$1,556.95	
Manchester National Bank....	7,101.46	
Manchester Savings Bank....	9,439.08	
		$18,097.49

Fund Statement.

CONANT FUND.

Receipts	$2,805.00
Expenditures	2,805.00

LAND GRANT.

Receipts		$4,800.00
Pres. and Sec.: Salaries.....	$2,920.88	
Mod. Lang.: Instruction....	1,879.12	4,800.00

ROSECRANS W. PILLSBURY FUND.

Cash on hand July 1, 1907.....	$26.25	
Receipts	7.00	
		$33.25

STUDENT LOAN FUND.

Receipts	$300.00	
Interest	2.00	
	$302.00	
Expenditures	$300.00	
Balance		$2.00

*Several hundred dollars in interest have been saved to the State during the past year by using current funds early in the year to pay old indebtedness and by reborrowing later as the money was needed. For details see Treasurer's Report.

HAMILTON SMITH FUND.

Receipts		$400.00	
Expenditures		400.00	

MORRILL FUND.

Receipts		$30,000.00	
Expenditures—			
Agri. Sci. Dept.	$1,663.30		
Horticultural Dept.	1,182.61		
Forestry Dept.	54.78		
Animal Husb. Dept.	600.00		
Dairy Dept.	962.49		
Creamery Dept.	19.60		
Mech. Eng. Dept.	2,834.67		
Elect. Eng. Dept.	3,261.57		
Drawing Dept.	2,293.47		
Shop Work	1,645.00		
Eng. Lang. Dept.	1,534.81		
Math. Sci. Dept.	2,544.61		
Chemical Dept.	5,211.64		
Phys. Sci. Dept.	1,952.13		
Botanical Dept.	851.53		
Zoological Dept.	1,915.93		
Econ. Sci. Dept.	1,466.86		
		$30,000.00	

LIBRARY FUND.

Balance on hand July 1, 1907		$1,249.87	
Expenditures		1,190.07	
Balance on hand July 2, 1908			$59.80

STATE APPROPRIATION, (ORDINARY).

Receipts			$13,000.00
Expenditures—			
Pres. and Sec.: Salaries		$2,460.02	
Curator: Expense		8.21	
Labor		1,046.08	
Salary		849.92	
Supplies		67.30	
Freight and Express		1.08	

Eng. Lang.: Instruction....	$266.65	
Freight and Express....	.25	
Econ. Sci.: Instruction......	600.00	
Roads and Grounds.........	697.55	
Advertising	153.46	
Clerical Work	200.00	
Freight and Express........	526.14	
Fire Insurance Premiums...	959.08	
Post., Sta., and Ptg.........	997.55	
Forestry: Tools	1.92	
Math. Sci.: Freight and Express	.30	
Contingent Expenses	227.07	
Farm: Labor	1,763.65	
Hort.: Labor	1,370.95	
Forestry: Labor	802.82	
		$13,000.00

STATE APPROPRIATION, (SPECIAL).

Receipts		$34,000.00
Expenditures—		
Dormitory	$9,629.60	
Library	8,337.07	
New Boilers	6,669.97	
Buildings and Repairs	2,540.51	
Furniture and Fixtures.....	633.04	
Library Grading	500.00	
Drake Land Purchase	300.00	
Roads and Grounds	400.00	
Librarians' Salaries	1,026.63	
Coal	1,475.75	
		$31,512.57
Balance		$2,487.43

GENERAL FUND.

Receipts—		
Cash on hand July 1, 1907..	$121.26	
W. D. Gibbs, President.....	23,571.29	
Lucien Thompson, Treasurer Real Estate Committee...	106.13	

Interest Frederick Smythe Fund	$80.00	
	$23,878.68	
Expenditures	23,732.37	
Balance		$146.31

MRS. SHERLY ONDERDONK FUND.

Receipts	$16,000.00	
Expenditures	3,820.00	
Balance on hand July 2, 1908..		$12,180.00

MISCELLANEOUS INCOME: EXPERIMENT STATION.

Receipts	$1,994.46	
Expenditures	1,993.82	
Balance		$ .64

HATCH FUND.

Receipts	$15,000.00	
Expenditures	14,998.42	
Balance		$1.58

ADAMS FUND.

Receipts	$9,000.00	
Expenditures	8,476.53	
Balance		$523.47

SUMMARY FUND BALANCES.

Rosecrans W. Pillsbury Fund......................	$33.25
Student Loan Fund	2.00
Library Fund	59.80
State Appropriation, (Special)	2,487.43
General Fund	146.31
Mrs. Sherly Onderdonk Fund......................	12,180.00
Mis. Inc.: Experiment Station	.64
Hatch Fund	1.58
Adams Fund	523.47
Cash on hand as per Treasurer's Report.............	$15,434.48

PRESIDENT'S FINANCIAL REPORT TO TRUSTEES.

W. D. Gibbs, President.

Summary of Transactions, July 1, 1906—June 30, 1907.

Income.

Receipts from Tuition, Fees, Farm, Creamery and Book Sales, deposited with Treasurer	$26,265.23

Expenditures by Schedules.

1906.					
*June	30.	Schedule	No.	35	$1,914.32
*	30,	"	"	36	965.39
July	16.	"	"	1	972.00
	31.	"	"	2	5,908.32
Aug.	10.	"	"	3	750.55
	15.	"	"	4	784.75
	31.	"	"	5	6,295.36
Sept.	8.	"	"	6	1,200.00
	15.	"	"	7	710.57
	29.	"	"	8	8,230.90
*Oct.	6.	"	"	9	2,119.79
	15.	"	"	10	632.92
	20.	"	"	11	4,000.00
	24.	"	"	12	1,336.17
	31.	"	"	13	8,204.28
Nov.	15.	"	"	14	592.16
	22.	"	"	15	4,593.70
	30.	"	"	16	6,631.35
Dec.	5.	"	"	17	400.00
	15.	"	"	18	648.94
	15.	"	"	19	120.00
	20.	"	"	20	3,000.00
	31.	"	"	21	6,658.10
1907.					
Jan.	15.	"	"	22	827.01
	15.	"	"	23	2,150.81
	31.	"	"	24	7,908.42
Feb.	15.	"	"	25	637.75
	20.	"	"	26	1,000.00
	28.	"	"	27	6,216.07

*See Treasurer's Report for 1906.

Mar.	15.	Schedule No.	28	$518.35	
	25.	" "	29	2,000.00	
	31	" "	30	7,456.02	
Apr.	15.	" "	31	710.26	
	30.	" "	32	7,424.92	
May	6.	" "	33	3,000.00	
	15.	" "	34	741.24	
	15.	" "	35	130.00	
	31.	" "	36	6,732.91	
June	15.	" "	37	1,614.40	
	30.	" "	1 Transfer.....	306.90	
	30.	" "	38	9,819.26	
	30.	" "	39	7,900.00	
					$133,764.39

Department Accounts.

AGRICULTURAL DEPARTMENT.

Agricultural Science Department, (Morrill).

	Receipts.	Expenditures.	
Agr. Sci.: Apparatus		$134.31	
Books		70.74	
Instruction		1,200.00	
Stock		337.48	
Animal Husbandry Instruction		550.01	
			$2,292.54

Agricultural Science Department, (General).

Agr. Sci.: Supplies		$17.77	
Freight and Express.		10.05	
Post., Sta., and Ptg..		7.50	
Traveling Expenses .		28.32	
Stock		8.82	
			$72.46

Farm Department, (Morrill).

Farm: Live Stock	$364.00		$364.00

Farm Department, (General).

		Receipts.	Expenditures.	
Farm:	Buildings and Repairs		$239.77	
	Blacksmithing		77.70	
	Feeding Stuffs		1,397.85	
	Freight and Express..		56.12	
	Heat, Light and Water		41.26	
	Labor		1,290.95	
	Live Stock		185.25	
	Supplies		152.35	
	Tools, etc.		53.98	
	Seeds		2.37	
	Sales	$2,861.39		
		$2,861.39	$3,497.60	$636.21

DAIRY DEPARTMENT.

Dairy Department, (Morrill).

Dairy;	Apparatus		$223.74	
	Instruction		522.80	
				$746.54

Dairy Department, (General).

Dairy:	Freight and Express..		$89.97	
	Furniture and Fixtures		26.40	
	Post., Sta., and Ptg...		43.15	
	Labor		428.60	
	Supplies		418.61	
	Heat, Light and Water		163.55	
	Milk		9,520.67	
	Sales	$10,714.69		
		$10,714.69	$10,690.95	+ $23.74

HORTICULTURAL DEPARTMENT.

Horticultural Department, (Morrill).

Hort.:	Apparatus	$36.30	
	Books ....'.....................	1.10	
	Instruction	940.28	
	Stock	.50	
			$978.18

Horticultural Department, (General).

	Receipts.	Expenditures.	
Hort.: Apparatus		$125.34	
Buildings and Repairs		401.71	
Feeding Stuffs		250.75	
Freight and Express		171.24	
Fertilizers		394.78	
Blacksmithing		42.05	
Labor		1,963.41	
Post., Sta., and Ptg...		31.49	
Seeds		257.79	
Supplies		736.30	
Tools, etc.		107.65	
Traveling Expenses..		36.09	
Sales	$2,367.00		
Live Stock		12.00	
	$2,367.00	$4,530.60	$2,163.60

Forestry Department, (General).

Forestry: Furniture and fixtures		$44.07	
Seeds		23.12	
Apparatus		20.24	
Labor		1,034.61	
Sales	$1,745.95		
Tools, etc		4.86	
Roads and Grounds...		10.50	
	$1,745.95	$1,137.40	+$608.55

Roads and Grounds, (General.)

Roads and Grounds....................		$1,028.10	$1,028.10

CHEMICAL DEPARTMENT.

Chemical Department, (Morrill).

Chem.: Books		$206.89	
Instruction		3,616.62	
Stock		578.86	
Apparatus		70.16	
			$4,472.53

Chemical Department, (General).

	Receipts.	Expenditures.	
Chem.: Apparatus		$7.25	
Freight and Express		41.01	
Post., Sta., and Ptg..		38.06	
Breakage Account ...	$493.29		
Supplies		1.22	
	$493.29	$87.54	+$405.75

MECHANICAL ENGINEERING DEPARTMENT.

Mechanical Engineering Department, (Morrill).

Mech. Eng.: Apparatus		$618.32	
Books		141.02	
Instruction		2,000.00	
Shop Work Instruction		1,985.49	
Stock		297.59	
			$5,042.42

Mechanical Engineering Department, (General).

Mech. Eng.: Apparatus.......		$2.00	
Freight and Express..		20.73	
Post., Sta., and Ptg...		5.30	
Supplies		14.65	
Sales	$64.07		
Traveling Expenses ..		19.33	
	$64.07	$62.01	+$2.06

Power and Service Department, (General).

P. and S.: Coal..............		$4,156.17	
Freight and Express..		217.98	
Post., Sta., and Ptg...		5.30	
Labor Sales	$266.67		
Supplies		1,562.48	
Tools		270.55	
Labor		2,869.63	
	$266.67	$9.082.11	$8,815.44

Curator's Department, (General)

Cura.: Expense		$23.34	
Labor		728.64	
Supplies		159.28	
Freight and Express..		2.20	
			$913.46

Buildings and Repairs, (General).

	Receipts.	Expenditures.	
Buildings and Repairs. Pres.			
House		$50.70	
General		813.46	
			$864.16

DRAWING DEPARTMENT.

Drawing Department, (Morrill).

Drawing: Instruction.........		$1,299.99	
Stock		11.94	
Apparatus		4.00	
Books		22.93	
			$1,338.86

Drawing Department, (General).

Drawing: Freight and Express.		$4.15	
Furniture and Fixtures		9.75	
Supplies		.45	
			$14.35

ELECTRICAL ENGINEERING DEPARTMENT.

Electrical Engineering Department, (Morrill).

Elec. Eng.: Apparatus		$561.64	
Instruction		1,359.96	
Stock		1.61	
			$1,923.21

Electrical Engineering Department, (General).

Elec. Eng.: Apparatus.......		$1.42	
Freight and Express.		28.67	
Traveling Expenses .		35.39	
Post., Sta., and Ptg..		25.34	
			$90.82

PHYSICAL SCIENCE DEPARTMENT.

Physical Science Department, (Morrill).

Phys. Sci.: Apparatus.......		$28.12	
Books		61.03	
Instruction		1,359.96	
Stock		2.25	
			$1,451.36

Physical Science Department, (General).

Phys. Sci.: Freight and Express.		$ .15	
Post., Sta., and Ptg.....		13.32	
Traveling Expenses		2.27	
			$15.74

ENGLISH LANGUAGE DEPARTMENT. ....

English Language Department, (Morrill).

	Receipts.	Expenditures.
Eng. Lang.: Books	$207.66	
Instruction	918.36	
		$1,126.02

English Language Department, (General).

Eng. Lang.: Instruction	$213.34	$213.34

Secretary of Faculty, (General).

Sec. of Fac.: Post., Sta., and Ptg	$21.50	
Freight and Express ...	.30	
		$21.80

MATHEMATICAL SCIENCE DEPARTMENT.

Mathematical Science Department, (Morrill).

Math. Sci.: Instruction	$2,131.27	
Apparatus	27.15	
		$2,158.42

Mathematical Science Department, (General).

Math. Sci.: Freight and Express.	$ .45	
Post., Sta., and Ptg.....	.60	
		$1.05

MODERN LANGUAGE DEPARTMENT.

Modern Language Department, (Land Grant).

Mod. Lang.: Instruction....	$1,400.00	$1,400.00

ECONOMIC SCIENCE DEPARTMENT.

Economic Science Department, (Morrill).

Econ. Sci.: Books..........	$112.66	
Instruction	1,400.00	
		$1,512.66

Economic Science Department, (General).

Econ. Sci.: Instruction.....	$600.00	$600.00

LIBRARY DEPARTMENT.

Library Department, (General).

Library: Clerical Work	$685.07	
Books	64.95	
Freight and Express ..	17.30	
Supplies	20.09	
Furniture and Fixtures	31.00	
		$818.41

ZOOLOGICAL DEPARTMENT.

Zoological Department, (Morrill).

	Receipts.	Expenditures.	
Zool.: Apparatus		$104.33	
Books		98.47	
Instruction		900.00	
Stock		37.86	
			$1,140.66

Zoological Department, (General).

	Receipts.	Expenditures.	
Zool.: Supplies		$48.61	
Traveling Expenses...		6.78	
Freight and Express..		16.45	
Furniture and Fixtures		10.54	
Labor		136.10	
Post., Sta., and Ptg..		4.50	
Laboratory	$38.88		
Buildings and Repairs		5.86	
	$38.88	$228.84	$189.96

MILITARY SCIENCE DEPARTMENT.

Military Science Department, (General).

	Receipts.	Expenditures.	
Mil. Sci.: Supplies		$91.22	
Freight and Express.		25.10	
Post., Sta., and Ptg..		15.75	
Band		140.15	
Labor		35.99	
			$308.21

BOTANICAL AND BACTERIOLOGICAL DEPARTMENT.

Botanical and Bacteriological Department, (Morrill).

	Receipts.	Expenditures.	
Bot. and Bact.: Apparatus ..		$152.60	
Instruction		300.00	
			$452.60

Botanical and Bacteriological Department, (General.)

	Receipts.	Expenditures.	
Bot. and Bact.: Stock		$2.12	
Freight and Express....		2.45	
Furniture and Fixtures.		5.00	
Labor		10.19	
Supplies		.67	
			$20.43

Miscellaneous Accounts, (General).

	Receipts.	Expenditures.	
Office Supplies		$41.39	
Advertising		420.52	
Athletic Appropriation		1,120.00	
Book Store		2,673.85	
Book Store: Sales...........	$2,845.34		
Chapel Expenses		134.27	
Clerical Work		207.95	
Commencement Expenses		293.55	
Conant Scholarships		2,845.00	
Contingent Expenses		546.86	
Freight and Express		634.47	
Furniture and Fixtures.......		337.07	
Fire Ins. Premiums..........		1,607.87	
Post., Sta., and Ptg..........		658.29	
Valentine Smith Scholarships		400.00	
Students' Fees	6,608.50		
Traveling Expenses		189.18	
Trustees Expenses		689.30	
Mis. Inc.: Exp. Station.......	165.84		
Erskine Mason Prize.........		4.00	
	$9,619.68	$12,803.57	$3,183.89

Miscellaneous Accounts, (Land Grant).

Pres. and Sec.: Salaries.......	$3,394.90	
Library: Books	5.10	
		$3,400.00

Miscellaneous Accounts, (New Library).

New Library	$31,638.13	$31,638.13

HATCH FUND.

Salaries	$7,907.63
Labor	2,641.24
Publications	1,195.87
Postage and Stationery	152.32
Freight and Express	189.59
Heat, Light and Water........	222.25
Chemical Supplies	124.08
Seeds and Sundry Supplies....	591.78
Fertilizers	231.02
Feeding Stuffs	20.17
Library	229.06
Tools, etc.	434.00

	Receipts.	Expenditures.	
Furniture and Fixtures		$56.17	
Scientific Apparatus		213.09	
Live Stock		206.17	
Traveling Expenses		453.22	
Contingent Expenses		16.16	
Buildings and Repairs.........		116.18	
			$15,000.00

ADAMS FUND.

Salaries	$4,556.60	
Labor	589.19	
Freight and Express	131.44	
Chemical Supplies	16.44	
Seeds and Sundry Supplies....	385.89	
Feeding Stuffs	146.93	
Tools, etc.	14.90	
Scientific Apparatus	615.26	
Live Stock	105.00	
Traveling Expenses	93.22	
Buildings and Repairs	345.13	
		$7,000.00

PRESIDENT'S FINANCIAL REPORT TO TRUSTEES.

W. D. Gibbs, President.

Summary of Transactions, July 1, 1907—July 2, 1908.

Income.

Receipts from Tuition, Fees, Farm, Creamery and Book Sales, deposited with Treasurer	$23,571.29

Expenditures by Schedules.

1907.				
July	15.	Schedule No. 1	$797.96	
	31.	" " 2	11,998.28	
Aug.	15.	" " 3	750.43	
	31.	" " 4	8,467.29	
Sept.	14.	" " 5	629.51	
	30.	" " 6	6,636.12	
Oct.	15.	" " 7	570.82	
	31.	" " 8	17,311.29	
Nov.	15.	" " 9	545.40	
	15.	" " 10	838.32	
	30.	" " 11	10,181.99	

1908.				
Dec.	16.	Schedule No. 12	$455.21	
	16.	" " 13	112.50	
	31.	" " 14	10,807.47	
Jan.	15.	" " 15	552.75	
	31.	" " 16	10,090.26	
	31.	" " 17	351.75	
Feb.	15.	" " 18	529.75	
	18.	" " 19	4,700.00	
	29.	" " 20	7,641.85	
Mar.	16.	" " 21	488.96	
	31.	" " 22	7,054.87	
	31.	" " 23	2,300.00	
Apr.	15.	" " 24	604.96	
	30.	" " 25	7,630.80	
May	5.	" " 26	3,820.00	
	15.	" " 27	87.50	
	15.	" " 28	642.09	
	30.	" " 29	8,274.04	
June	15.	" " 30	724.85	
	30.	" " 31	8,559.58	
				$134,157.10

Department Accounts.

AGRICULTURAL DEPARTMENT.

Agricultural Science Department, (Morrill).

	Receipts.	Expenditures.
Agr. Sci.: Apparatus.............	$143.30	
Books	67.94	
Instruction	1,383.38	
Stock	68.68	
Animal Husb. Instruction.	600.00	
		$2,263.30

Agricultural Science Department, (General).

Agr. Sci.: Labor................	$15.00	
Supplies	21.77	
Freight and Express.....	19.35	
Post., Sta., and Ptg.......	20.66	
Traveling Expenses	10.27	
		$87.05

Agricultural Science Department, ($34,000 State Appro.).

Agri. Sci.: Buildings and Repairs........	$21.66	$21.66

Farm Department, (General).

	Receipts.	Expenditures.	
Farm: Blacksmithing.........		$128.84	
Feeding Stuffs.......		1,733.43	
Freight and Express..		44.24	
Heat, Light and Water		40.62	
Fertilizers		64.94	
Labor Sales	$1,015.10		
Herd Sales	1,325.53		
Produce Sales	1,101.51		
Live Stock		218.89	
Supplies		195.64	
Tools		26.85	
Seeds		29.38	
Foreman's Salary....		414.96	
Traveling Expenses...		9.72	
	$3,442.14	$2,907.51	+ $534.63

Farm Department, ($34,000 State Appropriation).

Farm: Buildings and Repairs.		$95.15	$95.15

Farm Department, ($13,000 State Appropriation).

Farm: Labor		$1,763.65	$1,763.65

DAIRY DEPARTMENT.

Dairy Department, (Morrill).

Dairy: Apparatus		$308.78	
Instruction		625.00	
Stock		6.90	
Books		21.81	
			$962.49

Dairy Department, (General).

Dairy: Freight and Express..		$24.96	
Post., Sta., and Ptg..		4.12	
Tools		6.41	
Traveling Expenses...		3.43	
Labor		154.49	
Supplies		149.13	
Milk (to Sept. 14, '07)		1,738.00	
Sales (to Sept. 14, '07)	$2,247.89		
	$2,247.89	$2,080.54	+$167.35

Dairy Department, ($34,000 State Appro.).

	Receipts.	Expenditures.	
Dairy: Buildings and Repairs...		$6.76	
Furniture and Fixtures.		58.25	
			$65.01

Creamery Department. (General).

Creamery: Milk (from Sept. 14, '07)		$6,657.52	
Sales (from Sept. 14, '07)	$7,909.47		
Labor		576.86	
Post., Sta., and Ptg...		6.00	
Freight and Express..		33.66	
Supplies		195.99	
	$7,909.47	$7,470.03	+$439.44

Creamery Department. ($34,000 State Appropriation).

Creamery: Buildings and Repairs		$406.50	$406.50

Creamery Department, (Morrill).

Creamery: Apparatus		$19.60	$19.60

DRAWING DEPARTMENT.

Drawing Department, (Morrill).

Drawing: Instruction		$2,266.60	
Stock		4.99	
Books		26.88	
			$2,298.47

Drawing Department, (General).

Drawing: Traveling Expenses.		$12.52	
Freight and Express..		5.48	
Post., Sta., and Ptg....		5.50	
Supplies		1.29	
			$24.79

HORTICULTURAL DEPARTMENT.

Horticultural Department, (Morrill).

Hort.: Books		$26.93	
Instruction		1,153.88	
Stock		1.80	
			$1,182.61

Horticultural Department, (General).

	Receipts.	Expenditures.	
Hort.: Books................		$1.00	
Feeding Stuffs		241.06	
Fertilizers		204.47	
Freight and Express..		115.24	
Blacksmithing		79.25	
Post., Sta., and Ptg...		.87	
Seeds		479.93	
Supplies		375.24	
Tools		22.92	
Traveling Expenses...		22.74	
Sales	$2,319.88		
Foreman's Salary		300.00	
	$2,319.88	$1,842.72	+$477.16

Horticultural Department. ($34,000 State Appro.).

Hort.: Buildings and Repairs.		$286.64	$286.64

Horticultural Department, ($13,000 State Appro.).

Hort.: Labor		$1,370.95	$1,370.95

Forestry Department, (Morrill).

Forestry: Apparatus		$54.78	$54.78

Forestry Department, (General).

Forestry: Freight and Express		$1.35	
Sales	$212.59		
	$212.59	$1.35	+$211.24

Forestry Department, ($13,000 State Appro.).

Forestry: Labor		$802.82	
Tools		1.92	
			$804.74

Roads and Grounds Department, ($34,000 State Appro.).

Roads and Grounds		$900.00	$900.00

Roads and Grounds Department, ($13,000 State Appro.).

Roads and Grounds		$697.55	$697.55

CHEMICAL DEPARTMENT.

Chemical Department, (Morrill).

Chemistry: Apparatus		$3.80	
Books		129.79	
Instruction		4,533.30	
Stock		544.75	
			$5,211.64

Chemical Department, (General).

	Receipts.	Expenditures.	
Chemistry: Stock		$167.11	
Freight and Express..		47.37	
Post., Sta., and Ptg...		36.85	
Breakage Account....	$515.35		
Supplies		16.08	
	$515.35	$267.41	+$247.94

Chemical Department, ($34,000 State Appro.).

Chemistry: Furniture and Fixtures	$3.80	$3.80

ENGLISH LANGUAGE DEPARTMENT.

English Language Department, (Morrill).

Eng. Lang.: Books	$155.70	
Instruction	1,379.11	
		$1,534.81

English Language Department, (General).

Eng. Lang.: Post., Sta., and Ptg..	$8.30	
Books	1.40	
		$9.70

English Language Department, ($13,000 State Appro.).

Eng. Lang.: Instruction	$266.65	
Freight and Express.....	.25	
		$266.90

Secretary of Faculty, (General).

Sec. of Fac.: Post., Sta., and Ptg..	$7.10	
Traveling Expenses	8.80	
		$15.90

MATHEMATICAL SCIENCE DEPARTMENT.

Mathematical Science Department, (Morrill).

Math. Sci.: Instruction...........	$2,522.50	
Books	9.50	
Apparatus	12.61	
		$2,544.61

Mathematical Science Department, ($13,000 State Appro.).

Math. Sci.: Freight and Express.	$ .30	$ .30

MECHANICAL ENGINEERING DEPARTMENT.

Mechanical Engineering Department, (Morrill).

	Receipts.	Expenditures.	
Mech. Eng.: Apparatus		$434.26	
Books		109.48	
Instruction		2,000.00	
Shop Work Instruction		1,645.00	
Stock		290.93	
			$4,479.67

Mechanical Engineering Department, (General).

	Receipts.	Expenditures.	
Mech. Eng.: Stock		$2.40	
Freight and Express..		18.11	
Post., Sta., and Ptg...		17.61	
Supplies		10.98	
Sales	$41.92		
Labor		7.88	
	$41.92	$56.98	$15.06

Mechanical Engineering Department, ($34,000 State Appro.).

	Receipts.	Expenditures.	
Mech. Eng.: Buildings and Repairs		$57.59	
Furniture and Fixtures....		65.87	
			$123.46

Power and Service Department, (General).

	Receipts.	Expenditures.	
P. and S.: Coal		$1,253.58	
Freight and Express..		108.80	
Post., Sta., and Ptg...		5.31	
Labor Sales	$894.52		
Supplies		1,832.69	
Tools		531.55	
Labor		2,637.00	
Heat, Light and Water		9.00	
	$894.52	$6,377.93	$5,483.41

Power and Service Department, ($34,000 State Appro.).

	Receipts.	Expenditures.	
P. and S.: Coal		$1,475.75	$1,475.75

Curator's Department, ($13,000 State Appro.).

	Receipts.	Expenditures.	
Curator: Expense		$8.21	
Labor		1,046.08	
Salary		849.92	
Supplies		67.30	
Freight and Express		1.08	
			$1,972.59

Buildings and Repairs Department, ($34,000 State Appro.).

	Receipts.	Expenditures.	
B. and R.: Pres. House		$174.78	
General		1,416.05	
			$1,590.83

ELECTRICAL ENGINEERING DEPARTMENT.

Electrical Engineering Department, (Morrill).

Elec. Eng.: Apparatus		$847.92	
Books		14.00	
Instruction		2,108.30	
Stock		291.35	
			$3,261.57

Electrical Engineering Department, (General).

Elec. Eng.: Freight and Express		$57.33	
Traveling Expenses...		20.62	
Post., Sta., and Ptg...		18.13	
Supplies		1.35	
Labor Sales..........	$32.72		
	$32.72	$97.43	$64.71

Electrical Engineering Department, ($34,000 State Appro.).

Phys. Sci.: Apparatus		$245.73	

PHYSICAL SCIENCE DEPARTMENT.

Physical Science Department, (Morrill).

Phys. Sci.: Freight and Express		$245.73	
Books		70.30	
Instruction		1,608.30	
Stock		27.80	
			$1,952.13

Physical Science Department, (General).

Phys. Sci.: Freight and Express		$ .40	
Post., Sta., and Ptg..		5.81	
Labor Sales..........	$24.21		
	$24.21.	$6.21	+$18.00

Physical Science Department, ($34,000 State Appro.).

Phys. Sci.: Furniture and Fixtures		$8.00	$8.00

MODERN LANGUAGE DEPARTMENT.

Modern Language Department, (Land Grant).

	Receipts.	Expenditures.	
Mod. Lang.: Instruction......		$1,879.12	$1,879.12

Modern Language Department, (General).

	Receipts.	Expenditures.	
Mod. Lang.: Books		$28.40	$28.40

ECONOMIC SCIENCE DEPARTMENT.

Economic Science Department, (Morrill).

	Receipts.	Expenditures.	
Econ. Sci.: Books............		$66.86	
Instruction		1,400.00	
			$1,466.86

Economic Science Department, ($13,000 State Appropriation.)

	Receipts.	Expenditures.	
Econ. Sci.: Instruction.......		$600.00	$600.00

LIBRARY DEPARTMENT.

Library Department, (General).

	Receipts.	Expenditures.	
Library: Clerical Work.......		$1.00	
Books		58.00	
Freight and Express..		29.63	
Post., Sta., and Ptg...		7.86	
Supplies		158.14	
Fees	$20.00		
	$20.00	$254.63	$234.63

Library Department, ($34,000 State Appropriation).

	Receipts.	Expenditures.	
Library: Salary		$1,026.63	$1,026.63

ZOOLOGICAL DEPARTMENT.

Zoological Department, (Morrill).

	Receipts.	Expenditures.	
Zoology: Apparatus		$5.75	
Books		92.30	
Instruction		1,773.77	
Stock		44.11	
			$1,915.93

Zoological Department, (General).

	Receipts.	Expenditures.	
Zoology: Supplies		$21.20	
Freight and Express.		28.37	
Labor		22.81	
Post., Sta., and Ptg....		9.40	
Laboratory		.10	
			$81.88

Zoological Department, ($34,000 State Appropriation).

		Receipts.	Expenditures.
Zoology: Furniture and Fixtures		$216.59	$216.59

MILITARY SCIENCE DEPARTMENT.

Military Science Department, (General).

Mil. Sci.: Supplies		$8.23	
Freight and Express.		2.51	
Post., Sta., and Ptg...		9.89	
Band		46.25	
Labor		39.36	
Traveling Expenses		2.48	
Books		16.31	
			$125.03

BOTANY AND BACTERIOLOGICAL DEPARTMENT.

Botany and Bacteriological Department, (Morrill).

Bot. and Bact.: Books		$38.90	
Instruction		728.78	
Apparatus		82.35	
Stock		1.50	
			$851.53

Botany and Bacteriological Department, (General).

Bot. and Bact.: Freight and Express		$2.53	
Post., Sta., and Ptg...		1.86	
Labor		9.20	
Laboratory	$5.04		
Supplies		13.58	
	$5.04	$27.17	$22.13

Botany and Bacteriological Department, ($34,000 State Appro.).

Bot. and Bact.: Furniture and Fixtures..		$14.25	
Buildings and Repairs		75.38	
			$89.63

MISCELLANEOUS ACCOUNTS, (GENERAL.)

	Receipts.	Expenditures.	
Athletic Appropriation		$1,095.00	
Book Store		2,370.09	
Book Store: Sales	$2,461.33		
Chapel Expenses		135.00	
Commencement Expenses		309.57	
Office Supplies		34.07	
Student Fees	6,736.00		
Erskine Mason Prize.........		4.00	
Traveling Expenses		462.35	
Trustees' Expenses		428.70	
Smythe Book Fund		67.20	
Student Loan Fund	$2.00		
	$9,199.33	$4,905.98	+$4,293.35

MISCELLANEOUS ACCOUNTS. (LAND GRANT).

Pres. and Sec.: Salaries	$2,920.88	$2,920.88

MISCELLANEOUS ACCOUNTS. (HAMILTON SMITH FUND).

Valentine Smith Scholarships.	$400.00	$400.00

MISCELLANEOUS ACCOUNTS. (CONANT FUND).

Conant Scholarships	$2,805.00	$2,805.00

MISCELLANEOUS ACCOUNTS. (LIBRARY FUND).

New Library	$1,190.07	$1,190.07

MISCELLANEOUS ACCOUNTS. (MRS. ONDERDONK FUND).

Dormitory	$3,820.00	$3,820.00

MISCELLANEOUS ACCOUNTS. ($34,000 STATE APPROPRIATION).

Contingent Expenses (Drake land purchase	$300.00	
Furniture and Fixtures	258.28	
New Library: Equipment ...	8,337.07	
New Boilers and Pipes......	6,669.97	
Dormitory	9,629.60	
		$25,194.92

MISCELLANEOUS ACCOUNTS. ($13,000 STATE APPROPRIATION.)

Advertising	$153.46	
Clerical Work	200.00	
Contingent Expenses	227.07	
Freight and Express	526.14	
Fire Insurance Premiums...	959.08	
Post., Sta., and Ptg..........	997.55	
Pres. and Sec.: Salaries.....	2,460.02	
		$5,523.32

CATALOG.

CALENDAR.

1908

JULY

S	M	T	W	T	F	S
--	--	--	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	--

AUGUST

S	M	T	W	T	F	S
--	--	--	--	--	--	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	--	--	--	--	--

SEPTEMBER

S	M	T	W	T	F	S
--	--	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	--	--	--
--	--	--	--	--	--	--

OCTOBER

S	M	T	W	T	F	S
--	--	--	--	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
--	--	--	--	--	--	--

NOVEMBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	--	--	--	--	--
--	--	--	--	--	--	--

DECEMBER

S	M	T	W	T	F	S
--	--	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	--	--
--	--	--	--	--	--	--

1909

JANUARY

S	M	T	W	T	F	S
--	--	--	--	--	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	--	--	--	--	--	--

FEBRUARY

S	M	T	W	T	F	S
--	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	--	--	--	--	--	--
--	--	--	--	--	--	--

MARCH

S	M	T	W	T	F	S
--	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	--	--	--
--	--	--	--	--	--	--

APRIL

S	M	T	W	T	F	S
--	--	--	--	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	--
--	--	--	--	--	--	--

MAY

S	M	T	W	T	F	S
--	--	--	--	--	--	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	--	--	--	--	--

JUNE

S	M	T	W	T	F	S
--	--	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	--	--	--
--	--	--	--	--	--	--

JULY

S	M	T	W	T	F	S
--	--	--	--	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
--	--	--	--	--	--	--

AUGUST

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	--	--	--	--
--	--	--	--	--	--	--

SEPTEMBER

S	M	T	W	T	F	S
--	--	--	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	--	--
--	--	--	--	--	--	--

OCTOBER

S	M	T	W	T	F	S
--	--	--	--	--	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	--	--	--	--	--	--

NOVEMBER

S	M	T	W	T	F	S
--	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	--	--	--	--
--	--	--	--	--	--	--

DECEMBER

S	M	T	W	T	F	S
--	--	--	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	--
--	--	--	--	--	--	--

1910

JANUARY

S	M	T	W	T	F	S
--	--	--	--	--	--	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	--	--	--	--	--

FEBRUARY

S	M	T	W	T	F	S
--	--	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	--	--	--	--	--
--	--	--	--	--	--	--

MARCH

S	M	T	W	T	F	S
--	--	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	--	--
--	--	--	--	--	--	--

APRIL

S	M	T	W	T	F	S
--	--	--	--	--	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
--	--	--	--	--	--	--

MAY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	--	--	--	--
--	--	--	--	--	--	--

JUNE

S	M	T	W	T	F	S
--	--	--	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	--	--
--	--	--	--	--	--	--

COLLEGE CALENDAR.

1908.

Sept.	14-15.	Entrance examinations begin Monday at 9 a. m.
Sept.	16.	Registration, Wednesday. First semester begins.
Oct.	7.	Stated meeting of Trustees.
Dec.	18.	College closes Friday night.

CHRISTMAS VACATION.

1909.

Jan.	5.	College opens Tuesday, at 8 a. m.
Jan.	13.	Stated meeting of Trustees.
Feb.	1-5.	Mid-year examinations.

WINTER VACATION.

Feb.	10.	Registration, Wednesday. Second semester begins.
Apr.	14.	Stated meeting of Trustees.
Apr.		College closes Wednesday night preceding Fast Day.

SPRING VACATION.

Apr.		College opens Tuesday following Fast Day, at 8 a. m.
June	8.	Senior examinations completed 4 p. m.
June	9-14.	Final examinations.
June	13.	Baccalaureate sermon, Sunday at 10.45 a. m.
June	14.	Prize Drill, 8 p. m., in the Armory.
June	15.	Class Day. Stated meeting of Trustees.
June	16.	Commencement Day. Senior promenade at 8 p. m.

SUMMER VACATION.

Sept.	10-14.	Examinations for admission begin Friday at 9 a. m.
Sept.	15.	Registration, Wednesday. First semester begins.
Oct.	13.	Stated meeting of Trustees.
Dec.	17.	College closes Friday night.

CHRISTMAS VACATION.

1910.

Jan.	4.	College opens Tuesday at 8 a. m.
Jan.	12.	Stated Meeting of Trustees.
Jan.	31—Feb. 4.	Mid-year examinations.

WINTER VACATION.

Feb.	9.	Registration, Wednesday. Second semester begins.

BOARD OF TRUSTEES.

OFFICERS OF INSTRUCTION AND ADMINISTRATION.

WILLIAM D. GIBBS, D. Sc., President of the College.

CHARLES H. PETTEE, A. M., C. E., *Dean and Professor of Mathematics*.

CLARENCE W. SCOTT, A. M., *Professor of History and Political Economy*.

FRED W. MORSE, M. S., *Professor of Organic Chemistry*.

CHARLES L. PARSONS, B. S., *Professor of Inorganic Chemistry.*

FREDERICK W. TAYLOR, B. Sc. (Agr.), *Professor of Agronomy.*

E. DWIGHT SANDERSON, B. S., B. S. Agr., *Professor of Zoology and Entomology and Director of the Experiment Station.*

ARTHUR F. NESBIT, S. B., A. M., *Professor of Physics.*

WILLIAM E. HUNT, B. S., *Captain Twenty-Second U. S. Infantry, Professor of Military Science and Tactics.*

RICHARD WHORISKEY, Jr., A. B., *Professor of Modern Languages.*

FREDERICK W. PUTNAM, B. S., *Professor of Drawing and Design.*

CHARLES BROOKS, Ph. D., *Professor of Botany.*

CHARLES E. HEWITT, B. S., M. M. E., *Professor of Electrical Engineering.*

BETHEL S. PICKETT, B. S., *Professor of Horticulture.*

ERNEST R. GROVES, A. B., B. D., *Professor of English and Philosophy.*

FORREST E. CARDULLO, M. E., *Professor of Mechanical Engineering.*

FRED RASMUSSEN, B. S. A., *Associate Professor of Dairying.*

WILLIAM H. PEW, B. Sc. (Agr.), *Associate Professor of Animal Husbandry.*

CHARLES JAMES, F. I. C., *Assistant Professor of Inorganic Chemistry.*

A. M. BUCK, M. E., *Assistant Professor of Electrical Engineering.*

FRANK R. BROWN, B. S., *Instructor in Machine Work.*

DAVID L. RANDALL, Ph. D., *Instructor in Chemistry.*

RAY A. SPENCER, A. B., *Instructor in English and Modern Languages.*

HARRY E. INGHAM, B. S., *Instructor in Wood Work.*

THOMAS J. LATON, B. S., *Instructor in Drawing.*

WILLIAM M. BARROWS, B. S., S. M., *Instructor in Zoology.*

C. FLOYD JACKSON, B. S., M. A., *Instructor in Entomology.*

ISAAC M. LEWIS, A. B., A. M., *Instructor in Botany.*

JASPER F. EASTMAN, B. S., *Assistant in Agronomy.*

WILLIAM H. WICKS, M. S. (Agr.), *Assistant in Horticulture.*

JOHN C. McNUTT, B. S. (Agr.), *Assistant in Animal Husbandry, Herdsman.*

OSCAR W. STRAW, *Engineer and Curator of Buildings.*

DAVID LUMSDEN, *Foreman of Gardens and Greenhouse.*

GEORGE S. HAM, *Farm Foreman.*

MABEL E. TOWNSEND, A. B., *Registrar.*

MABEL HODGKINS, A. B., *Librarian.*

CHARLOTTE A. THOMPSON, *Assistant Librarian.*
NELLIE F. WHITEHEAD, *Purchasing Agent.*
LAVINIA BROWN, *Bookkeeper.*
MARCIA SANDERS, *Matron of Smith Hall.*

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

Hon. JOHN G. TALLANT, *Chairman,*	Pembroke
CHARLES W. STONE, A. M., *Secretary,*	East Andover
Hon. WARREN BROWN,	Hampton Falls
Hon. N. J. BACHELDER, A. M., M. S.,	East Andover
Pres. WILLIAM D. GIBBS, D. Sc., *ex officio,*	Durham

THE STATION STAFF.

E. DWIGHT SANDERSON, B. S., B. S. Agr., *Director and Entomologist.*
FRED W. MORSE, M. S., *Vice-Director and Chemist.*
FREDERICK W. TAYLOR, B. Sc. (Agr.), *Agriculturist.*
CHARLES BROOKS, Ph. D., *Botanist.*
FRED RASMUSSEN, B. S. A., *Dairyman.*
WILLIAM H. PEW, B. Sc. (Agr.), *Animal Husbandman.*
BETHEL S. PICKETT, B. S., *Horticulturist.*
BERT E. CURRY, M. S., *Associate Chemist.*
JASPER F. EASTMAN, B. S., *Assistant Agriculturist.*
C. FLOYD JACKSON, B. S., M. A., *Assistant Entomologist.*
WILLIAM H. WICKS, M. S. (Agr.), *Assistant Horticulturist.*
ISAAC M. LEWIS, A. B., A. M., *Assistant Botanist.*
DAVID LUMSDEN, *Assistant in Floriculture.*
JOHN C. McNUTT, B. S. (Agr.), *Herdsman.*
NELLIE F. WHITEHEAD, *Purchasing Agent.*
MABEL H. MEHAFFEY, *Stenographer.*
LAVINIA BROWN, *Bookkeeper.*

FOUNDATION AND ENDOWMENT.

The New Hampshire College of Agriculture and the Mechanic Arts was incorporated by the state legislature in 1866, under the

provisions of the act of Congress, approved July 2, 1862, entitled "An act donating public lands to the several states and territories which may provide colleges for the benefit of agriculture and the mechanic arts," the grant of land having been accepted by an act of legislature, approved July 9, 1863.

The act of 1862 provides that the income from the investment of the money realized from the sale of the lands shall be appropriated "to the endowment, support, and maintenance of at least one college where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, * * * in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

The "Morrill Bill," which was approved August 30, 1890, and received the assent of the state by an act of legislature, approved February 13, 1891, provides an appropriation for the more complete endowment and support of the colleges for the benefit of agriculture and the mechanic arts, established under the provisions of "the act of 1862."

The appropriation under the Morrill act is "to be applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their applications in the industries of life, and to the facilities for such instruction."

Under an act of Congress approved March 2, 1887, which received legislative assent August 4, 1887, was established that department of the college known as the Agricultural Experiment Station, the purpose of which was "to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science."

Benjamin Thompson, who died January 30, 1890, was a resident of Durham, and a farmer by profession. He had at heart the agricultural interests of his native state, and in the furtherance of those interests he bequeathed to it at his death his whole estate with a few minor reservations.

Mr. Thompson's final statement of the object of his bequest was as follows: "My object being mainly to promote the improvement of agriculture, though willing that the college to be established should also provide for the mechanic arts, it is my

will that the institution to be established by the state * * * shall be called and designated * * * The New Hampshire College of Agriculture and the Mechanic Arts, if that shall be the wish of the state; and that in addition to the instruction to be given therein, as provided by my said will, there shall be taught only such other arts or sciences as may be necessary to enable said state to fully avail itself of said donation of lands by the government in good faith, which two branches of instruction shall be the leading objects of said institution or college."

By the provisions of the will, the income from this source will not, however, become available until 1910. This endowment will amount at that time to nearly $800,000, the annual income from which will be about $32,000.

The state legislature accepted the Thompson bequest March 5, 1891, and on April 10, of the same year appropriated $100,000 for buildings. Approximately $50,000 was realized from the sale of property and from other sources. In 1893 an additional appropriation of $35,000 was made by the state for completing and furnishing the buildings. Accordingly, in 1893 the college was moved from its first home at Hanover to its present location at Durham.

The general government of the college is vested in a board of thirteen trustees. The governor of the state and the president of the college are trustees, *ex officio;* the alumni of the college elect one trustee; and all other trustees are appointed by the governor of the state, with the advice and consent of the council.

The college is executing the trust reposed in it by giving instruction in the various courses described in this catalog, under the prescribed heads of "agriculture" and "the mechanic arts."

SITUATION.

Durham, the present site of the college, is on the Western Division of the Boston and Maine Railroad, 62 miles from Boston, and about midway between Rockingham Junction and the City of Dover, being five miles from the latter place.

SUNDAY SERVICES.

Although the only church in Durham is nominally Congregational, it is attended by citizens of all denominations, and sectarian lines are never drawn. It is conveniently situated, and offers ample opportunity for religious observance.

GENERAL INFORMATION.

New Hampshire College offers the following courses:

1. Agricultural courses.
    a. Four year course.
    b. Two year course.
    c. Ten week course.
2. Mechanical Engineering Course.
3. Electrical Engineering Course.
4. Chemical Engineering Course.
5. General Course.

The college is a part of the public school system of the state. It stands in its agricultural, mechanical engineering, electrical engineering, technical chemistry, and general scientific courses, in the same relation to the high schools that the high schools stand to the grammar schools, and that these in turn stand to the elementary schools. In other words, it is a continuation of the grades of the public school system of the state, with special reference to the industrial pursuits, and, in the courses that are provided as described elsewhere in this catalog, it aims to give a practical training that shall fit the student to deal with the problems of life.

TUITION AND FEES.

Tuition is $60 a year; fees, which include all charges commonly considered extras, except those for breakage and damage to college property, are $20 a year. They are payable in advance in two equal instalments, one on the first day of each semester.

SCHOLARSHIPS.

Scholarships are awarded each semester at the discretion of the faculty to resident students of New Hampshire. They may be forfeited at any time for misconduct and will not be awarded except by special permission of the president, to students in the four year courses who have failed to secure an average grade of seventy or over in the previous semester. They are given for the purpose of aiding deserving students and will be withdrawn from those who use intoxicating liquors or tobacco.

Conant Scholarships.—There are twenty-five Conant scholarships, each paying tuition, $60, fees, $20, cash, $20,—total, $100. These are assigned under the following conditions:

They are to be given to young men taking an agricultural course.

Each town in Cheshire County is entitled to one scholarship, and Jaffrey is entitled to two.

They will be reserved for their respective towns until August 1 of each year. Those not taken by students from Cheshire County, and those in excess of the number of towns, will then be assigned to agricultural students from other parts of the state, and may be divided at the discretion of the president.

Senatorial Scholarships.—There are twenty-four senatorial scholarships,—one for each senatorial district. Each scholarship is to pay tuition, $60. Senatorial scholarships not filled may be assigned to students from other localities at the discretion of the faculty; they are open to students in all courses.

Grange Scholarships.—Each subordinate and Pomona grange in New Hampshire has the privilege of appointing one student annually to a free scholarship in any of the four year or two year courses in the college. Each scholarship is to pay the tuition of $60.

The method of appointment is entirely at the option of the grange; it may be by election, competitive examination, or otherwise. Holders of these scholarships need not be members of the grange.

Valentine Smith Scholarships.—Through the generosity of the late Mr. Hamilton Smith of Durham, the sum of $10,000 has been given to the college to establish the Valentine Smith scholarships.

"The income thus accruing to the college shall be given to the graduate of an approved high school or academy who shall, upon examination, be judged to have the most thorough preparation for admission to the college; *provided,*

"That the income shall be paid to the student to whom it is awarded, in eight semi-annual payments, at the time appointed for the payment of term bills; and

"That if the student receiving this scholarship shall at any time prove unworthy, in the judgment of the faculty, by reason of defective scholarship or character, he shall forfeit his claim to the student most deserving; and

"That if the student receiving this scholarship shall cease to be a member of the college, the income from this fund, for the unexpired term, shall be awarded to the student most deserving in character and scholarship."

By vote of the faculty, these scholarships will be forfeited by failure to obtain an average grade of 75 per cent. for any semester.

These scholarships yield $400 annually or one hundred dollars to each holder.

Competitive examinations for this scholarship will be held at the college at the time of the entrance examinations in September, and at no other time. They are not restricted to residents of New Hampshire.

PRIZES.

Bailey Prize.—Dr. C. H. Bailey, of Gardner, Mass., and E. A. Bailey, B. S., of Keene, N. H., offer a prize of ten dollars for proficiency in chemistry.

Erskine Mason Memorial Prize.—Mrs. Erskine Mason of Stamford, Conn., has invested one hundred dollars as a memorial to her son, a member of the class of 1893, the income of which is to be given, for the present, to that member of the senior class who has made the greatest improvement during his course.

COLLEGE AID TO STUDENTS.

Students obtain considerable financial aid by janitorships, and work on the farm and in the greenhouse. They also find employment with the power and service department of the college and with the experiment station.

ESTIMATE OF FRESHMAN EXPENSES.

Tuition,	Free	$60.00
Text-books,	$10.00 to	25.00
Military uniform for new students,	16.00 to	16.00
Drawing instruments and materials,	10.00 to	25.00
Fees,	20.00 to	20.00
Room rent, including heat and light,	30.00 to	50.00
Board, $3 to $3.50 per week, for thirty-six weeks,	108.00 to	126.50
Total,	$194.00	$322.50

Room rent is estimated on the supposition that two students occupy the same room or suite of rooms.

The college has no rooms for men students. Rooms may be obtained either furnished or unfurnished, in buildings under private control, and are for the most part provided with heating apparatus, electric lights and baths.

Women students, unless living at home, are required to room in Smith Hall, the woman's dormitory. Circulars giving terms, etc., may be obtained from the Registrar, New Hampshire College, Durham, New Hampshire.

REGISTRATION.

All undergraduate students who desire to attend the college during a given semester are required to register at the registrar's office before 4 p. m. of the first day of such semester. Every former student registered after the first day of any semester shall be charged for such registration a fine of one dollar for the first day and fifty cents additional for each succeeding day, to be remitted only by the president upon presentation of a substantial excuse for the delay.

ELECTION OF STUDIES.

Every student shall, on or before the Saturday before the last in each semester, notify in writing the secretary of the faculty of his elections for the semester following. Any student who, having made his elections, desires to change, shall make application to the faculty in writing with a statement in full of his reasons.

Any student who fails to fill out his elective slip on or before the date mentioned shall pay a fine of one dollar before he can be registered for the studies of the next semester, unless he has previously obtained from the secretary of the faculty a written excuse for delay.

No student shall be permitted to make changes in courses elected by him after one week from the time of his registration in each semester, except by vote of the faculty and the payment of one dollar.

ATTENDANCE AND EXCUSES.

All male students, unless members of the senior class or physically unfit, are required to attend military drill.

All students are required to attend chapel exercises. Students accumulating more than six unexcused absences from chapel during any semester shall be placed on probation.

Attendance upon class work is, in general, under the control of the heads of departments concerned. However, excuses for absence for one day or more, may be obtained of the dean in advance, and should be passed to the registrar by the student not later than twenty-four hours after the termination of such

absence. Excuses for absence for less than one day should be obtained of the instructors concerned. If excuses are for an indefinite time, the student must report to the registrar within twenty-four hours after his return to his studies, if he wishes to receive credit for his excuses.

In no case will such excuse relieve the student from class work.

Any head of a department may, without faculty action, exclude from examination any student who has been absent from twenty per cent. of the exercises of any class under his charge.

All classes shall begin at seven minutes after the hour scheduled, and close promptly at the end of the hour.

AMOUNT OF WORK.

No student shall be permitted to carry less than sixteen or more than twenty-two credit hours per week of classroom work or its equivalent, without the consent of the faculty.

REMOVAL OF DEFICIENCIES BY EXAMINATION.

Students conditioned on entrance examinations may have an opportunity to make up such deficiencies upon the three days preceding the beginning of each semester, and upon the last Saturday of each semester. A student who takes a deficiency examination upon an entrance subject at any other time must pay the college one dollar for each examination upon each subject.

Students who have any entrance condition outstanding at the beginning of the third year of residence at the college or more than one at the beginning of the second year shall not be allowed to register until such conditions have been removed.

Dates for re-examination in conditioned subjects are fixed at the discretion of the instructor. No requests for examinations will be granted on less than two weeks' notice except on the regular dates for examinations in entrance deficiencies.

BUILDINGS.

THOMPSON HALL.

Thompson Hall, the main college building has a length of 128 feet, exclusive of a *porte-cochère* 40 feet long, and a width of 93 feet in the widest part. It is built of granite and brick, and has three stories besides the basement.

The basement contains a blower-room, with apparatus for controlling the heating and ventilation of the building, a geological laboratory, a lavatory, and storage rooms.

One half of the first floor is occupied by the mechanical and free hand drawing and machine design rooms. The remainder of the first floor is used for offices, recitation rooms for mathematics and history, and a waiting room for women.

On the second floor are more offices, the zoological laboratories and recitation rooms for biology, mechanical engineering, English and modern languages.

On the third floor are the large hall used as an auditorium, two society rooms, and the bell-boy's room.

The building is lighted by gas and electricity, and provided with the most approved system of heating and ventilation.

LIBRARY BUILDING.

The library building, completed this year, was made possible by the generosity of Mr. Andrew Carnegie and by an act of consolidation whereby the college assumed the care of the Durham libraries and added to its building fund a sum of money which Mr. Hamilton Smith, late of Durham, provided for a public library building. It is a two-story building, with a frontage of 75 feet and a depth of 65 feet, not including the stack extension, which gives shelving room for sixty thousand volumes. On the main floor are the delivery, reference, reading, and children's rooms and the librarian's office. The second floor is used for seminar and lecture rooms. The stack room is fitted with a three-story stack, the second floor being on a level with the main floor of the library.

MORRILL HALL.

This building was erected in 1902 at a cost of about $30,000. It is 110 feet long and 58 feet wide, comprising four stories, including the basement. The material is brick, laid in Flemish bond, with trimmings of the clear, almost white Suncook granite. The roof is of slate, and the construction throughout is designed to give the greatest possible security against fire. All the partition walls are of brick, and the steam for heating is taken from the boilers at the central station, near the mechanical building.

The basement contains an agricultural museum, a live stock judging room, a bulletin mailing room, and a soil storage room.

The first floor is occupied by the department of agriculture. It contains two class rooms—one for agronomy and one for ani-

mal industry—a soil physics laboratory with a preparation room attached, and offices. The agricultural experiment station library of over 1,000 volumes and the office of the director of the agricultural experiment station are also on this floor.

The second floor is occupied by the horticultural department. It contains one class-room, a pomological laboratory, a forestry laboratory, a herbarium room, a horticultural and agricultural reading-room and offices. The second floor is also provided with a refrigerator room, in which the fruits and vegetables used for laboratory work may be preserved.

CONANT HALL.

Conant Hall contains the laboratories and lecture-rooms for instruction in chemistry, physics and electrical engineering. It is a substantial brick building, 92 by 70 feet, and three stories high, including the basement. It is heated by steam brought from the shops, lighted by gas and electricity and provided with a system of thorough ventilation. Water, gas, high pressure steam, hydrogen, oxygen, vacuum and blast are supplied through pipes wherever needed, and the lecture rooms in addition have switches controlling both dynamo and battery currents, and arrangements for stereopticon illustration.

The basement contains a small workshop, the battery, photometer, photographic and comparator rooms, a clock room protected by double walls against changes in temperature, an acid room and a water and gas laboratory provided with the necessary fixtures and appliances.

The first floor, with the exception of one room, is occupied by the departments of physics and electrical engineering. It contains the mineralogical laboratory, which is provided with tile-covered desks and other facilities for blowpipe analysis; the junior physical laboratory; an apparatus room; the department libraries of physical and electrical books and periodicals; an electrical laboratory; and the physical lecture room.

The second floor is given up entirely to the chemical department. It contains storerooms, an organic laboratory, a qualitative laboratory, a private laboratory, a dark room for polariscopic and spectroscopic work, a lecture-room provided with facilities as before described, a quantitative laboratory, and a room for the delicate chemical balances and most important reference works.

The laboratories are fitted up with modern accessories and with special reference to the kind of work to be performed in each.

SHOPS.

These have been built in order to provide facilities for instruction in the working of wood and metals. The buildings are constructed on the "slow burning" principle, with thick walls, and heavy, continuous plank floors.

The main building is 42 by 106 feet, and two stories high, with a basement 31 by 42 feet. The basement and westerly rooms are used as an engine room and mechanical laboratories. On the first floor is the machine shop and on the second are the wood shop and stock and pattern room.

Joined to the main shop building and on a level with its basement is a one-story building, 40 by 100 feet, containing the boiler room, forge shop and foundry.

There are three boilers, aggregating 360 horse-power, which furnish steam to all the college buildings, wherever needed for heating or power. A brick chimney, 95 feet high, carries away the waste gases from the furnaces.

THE ARMORY.

The armory is a brick building with granite trimmings, 61 by 99 feet, with a headhouse, 31 by 46 feet. In the basement are two bathrooms, containing shower baths, one for the use of the faculty and visiting teams, and the other for students. Adjoining these are a locker room, a drying room, a toilet room and a room for gymnasium supplies. There is also a space reserved for a swimming pool, bowling alley, ball cage, etc., to be completed at some future time.

On the first floor are the military lecture room, three offices and the drill hall or gymnasium, with a running track six feet wide.

The equipment of the gymnasium includes chest weights, dumb bells, Indian clubs, wands, bucks, horses, horizontal and parallel bars, travelling rings, ladders, punching bags, etc.

On the second floor of the headhouse are the college club rooms.

NESMITH HALL.

Nesmith Hall, a two-story brick building, is occupied by the chemical, botanical and dairy departments of the agricultural experiment station. It contains the offices, libraries and laboratories of the chemical and botanical departments and the office of the dairy department. The recitation room of the botanical department is also in this building.

DAIRY.

The dairy building is a wooden structure of one and one-half stories, with basement. It contains six rooms equipped for manual training in milk testing, milk and cream pasteurizing, cream ripening, butter-making and the care and management of dairy machinery.

The first floor is used for receiving milk and for the separators. On this floor are also the office of the associate professor of dairying and the laboratory for milk testing. The basement contains the ripening vats, churns and refrigerators, together with the engine.

BARNS.

The dairy barn is a large wooden structure, 45 by 100 feet, two stories high, and with a basement in which are box stalls, calf and sheep pens, a cold storage room, root cellar, feed, dressing and milk rooms. A story and a half ell, 35 by 100 feet, with basement, is attached to the main structure. The first floor of the ell is on a level with the basement of the main barn and contains stalls to accommodate 56 head of cattle. The basement of the ell contains pig pens, while the loft is used for the storage of feed, fertilizers and machinery. With the exception of the space occupied by a granary, a 120-ton silo and a 12-foot driveway, the upper floors of the main barn are used entirely for hay and forage, there being capacity for about 175 tons.

A new sheep barn built in the summer of 1907, houses about 80 sheep; the pens being sub-divided to accommodate those of different sizes. In this barn is storage room for twenty tons of hay and a considerable amount of grain.

A third barn is used by the agricultural department for the storage of hay, implements and wagons and for stabling the department horses.

A fourth barn, 25 by 60 feet, is used by the horticultural department for its horses and wagons and the storage of spraying machines and various garden implements.

GREENHOUSES.

The new range of greenhouses has been specially planned and built for carrying on modern and up-to-date work in greenhouse management and handicraft. There are seven houses, besides a propagating hallway. Connected with the glass structure is a workroom, 20 by 30 feet, which also answers as an office for the

florist, and is equipped with scales, seed-boxes and other accessories. The basement of the workroom, or potting house, is used for a boiler room and storeroom for potting soils. The whole is heated by steam and the houses are piped so that the temperature may be regulated for any kind of crop. One house is equipped for greenhouse management instruction and each student is given definite laboratory space and prescribed work. Two of the houses have ground beds and are adapted for forcing vegetables. The remaining houses have raised beds, excepting the center of the palm house, which has a ground bed.

These houses are lighted with electricity and offer unusual facilities for instruction and experimentation.

SMITH HALL.

Smith Hall, the woman's dormitory was made possible by the generosity of Mrs. Shirley Onderdonk, of Durham, who gave sixteen thousand dollars as a memorial to her mother, Mrs. Alice Hamilton Smith. The balance of the cost, $10,000, was provided by the state.

It is a three and one-half story brick building, 86 feet long by 36 feet deep, built in "Old English" style, with granite trimmings and gable roof. The main entrance faces the south and opens into a large hall-way.

On the right of the entrance is the dining room and to the left a handsome reception room. In the rear of the reception room are the office and apartments of the matron; back of the dining room are the serving room, kitchen and pantry. In the basement are the boiler room, trunk room, drying room, laundry, and rooms for storage and fuel. The second and third floors are for student accommodations, each floor being equipped to accommodate sixteen students, and provided with toilet rooms and baths (shower and tub).

The building is heated by steam and lighted by electricity. The interior finish is of stained cypress, with hard wood floors.

LABORATORIES AND EQUIPMENT.

AGRONOMY.

This department is provided with a collection of dried specimens of the different forage crops; the more important varieties of corn, wheat and oats; and with a large number of lantern

slides, grass charts and other illustrative material. The soil physics laboratory is equipped with soil bins, a compacting machine, chemical and torsion balances, and various kinds of physical apparatus for the study of soils, including that for the determination of specific gravity and for the making of mechanical analyses.

The agricultural museum contains many of the latest models of the different makes of farm machinery, tools and appliances, including plows, cultivators, harrows, mowers, rakes, corn and grain binders, threshers, manure spreaders, different kinds of cattle ties and various makes of patent wire fences.

The college farm, with its 300 acres of land, has a variety of soils and soil conditions suited to the growth of nearly all the important farm crops, and thus offers excellent opportunities for practical work and demonstration in the department of agronomy.

ANIMAL HUSBANDRY.

For the various courses in animal husbandry an extended use is made of the live stock of the college farm. The dairy herd consists of representative animals of the following breeds: Ayrshires, Guernseys, Jerseys, Holsteins and Shorthorns. The college owns seven head of horses representing the draft type, and to become acquainted with the standard bred types the students are taken to various stock farms where these types may be inspected and judged.

For the study of the different breeds of sheep and swine the experiment station flocks of pure bred Southdowns, Dorset Horns, Shropshires, Hampshires, Lincolns and Merinos and herds of Yorkshires are used.

In the agricultural building a large room is fitted up for the judging of live stock; instruments for precise measurements are provided and score cards with a scale of points for each kind of animal are used.

The class-room is provided with a stereopticon lantern and a large collection of lantern slides is used to show the leading individuals of several breeds of live stock. The herd books of the several breeds are made use of in familiarizing the student with methods of tracing pedigrees and the practices of breeders' associations.

HORTICULTURE.

The facilities for instruction in the various lines of horticulture have vastly improved during the past few years.

The lecture room is fitted up with a stereopticon lantern and the collection of lantern slides is being continually enlarged. The pomological and vegetable gardening laboratories are of original design and offer every facility for modern work. A great many varieties of vegetables are grown in the experiment station trial ground, and these offer exceptional opportunities for identification and study in the laboratory for some time after field conditions have gone by. The orchards, gardens and grounds also offer opportunities for demonstrating the theories advocated in the lecture-room. Many varieties of different kinds of fruit are to be found in the orchards. Grapes, apples, cherries and small fruits are also grown at the agricultural experiment station. Propagation of fruits, shrubs and flowering plants is practised. A fine collection of Vilmorin charts is owned by the department.

COLLEGE FOREST.

A tract of 60 acres of old forest growth is owned by the college. It is located close at hand and offers ample opportunities for studying forestry. The country about Durham presents forestry conditions typical of New England, and the transplanting of trees, sowing of seeds and general questions of forestry management may here be studied in Nature's laboratory.

DAIRYING.

All available space in the dairy building is filled with various forms of cream separators, churns, testing apparatus and other dairy appliances. In addition to the product of the college herd, milk is received from about 25 farms in Durham and vicinity. Through this arrangement the college is able to furnish plenty of milk for practice work and to provide for a most thorough and practical training in dairy and creamery management.

MECHANICAL ENGINEERING.

A 40 horse-power engine furnishes power for the shops and electric lights for the college buildings. A large compound duplex pump receives water under a head of 15 feet through an eight-inch pipe from a reservoir one-half mile distant, and forces it through underground mains to the various hydrants and buildings or through nozzles for measurements during tests. It is fitted with indicator motions and other necessary equipment for complete duty tests. The pump with its long supply pipe, a 10-inch standpipe and a 6000-gallon tank, furnish apparatus for an extensive series of hydraulic experiments.

Among other apparatus is a 50,000-pound Olsen machine with the necessary tools and measuring instruments for tension compression and transverse tests; a 12 horse-power gas engine; a Westinghouse air-brake pump with locomotive and tender attachments; steam and gas engine indicators; a surface condenser; a Bristol pyromoter; Pitot tubes; differential gauges; cement testing machine with the necessary sieves and other apparatus for testing cement according to the recommendations of the committee for cement testing; and the usual supply of scales, gauges, thermometers and small apparatus. The three 66″ return tubular boilers, with the 95 foot brick stack are used for boiler tests and flue gas analysis, by means of the Orsat apparatus, pyrometers and thermometers reading to 1,000 F. The boilers are fitted with forced draught apparatus, thus giving an opportunity for commercial tests with different grades of fuel, especially the cheaper grades. The ventilating fans and engines of the various buildings as well as the engines at the creamery, electrical laboratory and barn are available for testing. Opportunity is not only given for the student to test the engine or machine but to become familiar with its construction and operation.

In addition to the instruction given in the laboratory, excursions are made to various outside power plants, and when practicable, tests are made, thus enabling the student to become familiar with various types of engineering practice. Each year the proprietors of a nearby mill allow the class in valve gears to take exercises in valve setting on their 50 horse-power Corliss engine.

SHOPWORK.

The course in wood work consists of practice in carpentry, joinery and turning. Following this work is the course in pattern making, special attention being given to methods of design. The shop is supplied with benches and the necessary tools to accommodate twenty students at one time. Other equipment consists of a circular saw, board-planer, buzz-planer, jig-saw, speed-lathes, a large pattern maker's lathe with molding and boring attachments.

In the machine shop the student learns the principles of turning, facing, thread cutting, milling, shaping, scraping, filing and planing. In the advanced courses, parts of machinery are made to be used in the shops. The equipment is as follows: seven engine lathes, a 14-inch by 6-foot speed-lathe, built by students; a vertical drill, built by students; a 30-inch Flather

planer; a universal milling machine with gear-cutting and spiral attachments; shaper, power hack saw; tool grinder; 12 benches with vises, and a large number of small tools, including micrometer, calipers and gauges necessary for accurate work.

In the forge shop are 18 Sturtevant down-draft forges with anvils and necessary tools. The blast to the forges is furnished by a No. 4 blower, and the smoke carried away by a 60-inch exhauster. These are driven by a small steam engine. The student is taught the principles of forging, welding and tempering of iron and steel. Special attention is given to accuracy of dimensions as well as to shape and finish.

Foundry work is taken in connection with the course in pattern making, and the student molds and casts from the patterns he has constructed in the wood-shop. Castings are made in iron, brass and alloy, and tests are made on "test bars" of each. The foundry is supplied with a furnace, molding benches and bench tools.

PHYSICS.

The physical laboratory has a collection of the usual apparatus for laboratory work and lecture-room illustration, to which will be continually added pieces purchased or made in the college shop.

In the junior laboratory of physics there has been added apparatus for studying absorption phenomena and the comparison of spectra of films, liquids, metals, etc.; for measuring the angles of crystals and indices of refraction; for verifying the laws of refraction and total reflection of light; for determining the moment of inertia of various forms of specimens.

In electricity and magnetism the equipment includes instruments such as a magnetometer for studying the intensity of the earth's magnetism; a universal tangent galvanometer and an assortment of ammeters and voltmeters for measuring direct and alternating currents and voltages.

ELECTRICAL ENGINEERING.

The electrical engineering laboratories consist of two dynamo rooms, a transformer room, a photometer room and a storage battery room. In the main dynamo room there is a large distributing switchboard on which are mounted instruments, switches and plugging devices so arranged that it is possible to connect the laboratory rooms, also each lecture room, and convey thereto direct current and single phase, two phase and three phase alternating currents.

The general equipment of this department includes a magnetometer for studying the intensity of the earth's magnetism; a universal tangent galvanometer; a high grade four spool Thomson reflecting galvanometer; a D'Arsonal galvanometer; a Ryan electrometer for tracing pressure and current waves; a standard ballistic galvanometer; an Ayrton and Perry's variable standard of self-induction; as well as other types of instruments of various sizes for elementary work; also a complete Queen's photometer equipment for comparing incandescent and arc lamps and the distribution of light from the latter for open, enclosed and flaming arcs and when used with different forms of reflectors.

The equipment of the dynamo electric laboratory consists of 2 Edison bipolar 3 K. W. generators, an Edison bipolar 15 K. W. generator; a General Electric 4 pole 12 K. W. generator; a Crocker-Wheeler 3.5 K. W. generator, a Century 5 H. P. motor; a Westing house 5 H. P. motor with wound secondary; a Westinghouse 23 H. P. Junior type of engine; a Thompson-Houston 3 K. W. generator; two ¼ H. P. direct current motors; a low potential testing unit, consisting of a universal alternator belted to a direct current motor and capable of adjustment to be driven from either the direct or alternating current side; a ½ K. W. special alternator arranged for single, two and three phase currents connected either star or mesh; a storage battery of 60 cells, of the Cloride type, with special switchboard; various sizes and types of transformers; standard makes of voltmeters and ammeters having wide ranges; wattmeters; power-factor meters; phase indicators; hysteresis testing apparatus of the Holden-Esterlin type; high tension transformers for testing commercial value of various insulating materials and insulators; and various other testing instruments.

In connection with this department, there is a work shop equipped with a 14" 8 foot bed, Flather engine lathe with a complete set of attachments; a good set of wood and metal working tools; also a small speed lathe for drilling and wood working purposes, a union combination saw with scroll, molding and boring attachments, a small hand-driven metal planer and sensitive drill. This shop and its equipment are of great value in thesis work and in making new apparatus.

CHEMISTRY.

The several chemical laboratories are modern in design, commodious and well equipped. Each is supplied with the latest forms of apparatus required for its particular work. Besides

all necessary glass and porcelain ware, this includes water baths, drying ovens, combustion, muffle and assay furnaces, platinum dishes and crucibles, polariscope, spectroscope, balances, lantern and other lecture appliances, etc.

ZOOLOGY.

The zoological laboratory is well supplied with aquaria, microscopes, dissecting tools, charts, reference books and collections. The latter include a representative display of the birds of New Hampshire, and a very large collection of the insects of the state arranged in glass-covered boxes.

BOTANY.

The botanical laboratory is supplied with a good herbarium, charts, microscopes and the other necessary appliances.

SURVEYING.

The surveying instruments are sufficient in number and of the most approved pattern.

DRAWING.

One-half of the entire first floor in Thompson Hall is devoted to the use of the drawing and machine design department. For free-hand model-drawing and for mathematical drawing there is a good supply of geometric models; and for free-hand industrial drawing the nucleus of a good collection exists, consisting of plaster casts of historic ornament, details of human form and antique sculpture, as well as vases and common objects. There is an excellent collection of working models and machines for machine drawing and various machines in other departments are available for this work.

There is a good working library connected with this department, including reference books in mechanical and free-hand drawing and elementary and machine design.

MUSEUM.

The museum had for a nucleus the collection made during the state geological survey. To this additions have been made from various sources. Specimens are being collected to illustrate the zoology of New Hampshire, and New Hampshire collectors and naturalists are invited to make the museum the permanent depository for their collections.

LIBRARY.

In accordance with an act of consolidation between the libraries of Durham and the college, the books of the Durham Public Library and the college are all shelved in the new building. This consolidation makes an especially good collection, the scientific books of the college supplementing well the more popular books of the town library. The consolidated libraries number about 23,000 bound volumes and 7,000 pamphlets.

In the reading room are to be found the leading American and foreign periodicals, local papers and Boston and New York daily papers.

In the reference room are shelved about 2,000 bound volumes, which give good opportunity for reference and research work. There is also provision for the future in the second story rooms, which can be used for department libraries when the reference room proves inadequate.

Aside from the main library, each department has its department library of the more technical books and those which are of special use in the laboratories and work-shops.

MILITARY DEPARTMENT.

This department is in charge of an officer of the United States regular army, detailed by the war department, as professor of military science and tactics. Military instruction, which is required by law, is both theoretical and practical, the latter largely from September to December 1 and from April 1 to June, the former having special reference to the duties of the line.

The organization is a battalion of three companies with a band, officered by cadets selected for character, soldierly bearing and efficiency. The federal government has furnished Krag-Jorgensen magazine rifles, model 1898, and equipment for 200 men. Attention is paid to rifle practice, the government supplying ample ammunition and target materials, and the college a good range, within four minutes' walk of the college buildings, with firing points at 200, 300 and 500 yards. The rolling country in the vicinity of the college furnishes the best opportunities for extended order drill and field exercises, the athletic field for close order drills and the new gymnasium or drill shed gives ample room for indoor work.

The cadets wear, whenever on military duty, and may at other times, provided the complete uniforms are worn, cadet gray uniforms with black trouser stripes, black braid on cuffs and col-

lars of blouses and blue caps, army regulation. The letters N. H. C. are embroidered in gold on each side of blouse collar. The cost of such a uniform does not exceed $16 and the wearing of such does away with the necessity of purchasing a civilian suit for college use.

Service in this department is optional for members of the senior class; all other students, excepting those presenting surgeon's certificates of disability, are required to attend both drills and recitations. Seniors who elect drill and are appointed cadet officers have their college fees remitted.

Upon the graduation of each class, the names of such students as have shown special aptitude for military service are reported to the adjutant-general of the army and to the adjutant-general of the state. The names of the three most distinguished students in this department are inserted in the United States army register.

FOUR YEAR COURSES.

AGRICULTURAL COURSE.

This course is arranged especially for the general education and scientific training of students to fit them in various economic branches, such as agronomy, animal husbandry, dairying, biology, agricultural chemistry, entomology, forestry, horticulture, veterinary science, etc. Graduates are qualified to take positions as teachers and assistants in colleges and experiment stations, as farm superintendents, foremen, stock raisers, dairy farmers, creamery managers, dairymen, superintendents of estates, parks or cemeteries, fruit-growers, gardeners, florists, nurserymen, landscape gardeners, foresters, poultrymen, ranchmen, etc.

The aim is to give a broad general foundation of pure and applied science. Laboratory methods are used in connection with lecture and recitation work. Seminary courses are also given, especially for seniors and advanced students.

BIOLOGICAL DIVISION OF THE AGRICULTURAL COURSE.

The biological division of the agricultural course is for the benefit of those students who desire to make a special study of some phase of natural history. It leads to such positions as teachers of botany and zoology in high schools and colleges, entomologists for experiment stations, state inspectors of nursery grounds, etc. During the first two years the student pursues

the regular studies of the agricultural course, but in his junior year he begins to specialize in botany and zoology, a considerable proportion of his time during the rest of his course being given to these subjects. Students taking this course will elect, with the advice of the instructors in charge, six hours per week of biological work in the junior year and seven hours per week during the senior year, exclusive of thesis.

CHEMICAL DIVISION OF THE AGRICULTURAL COURSE.

The work of this division is especially intended to give a thorough grounding in the principles of chemistry as applied to agriculture and agricultural chemical analysis and to train the student thoroughly in all kinds of manipulation required of the chemist in experiment stations, large dairy establishments, fertilizer works, etc.

Instruction is given mainly by personal supervision in the laboratory, accompanied by lectures, themes, recitations; and, as in the course in technical chemistry, the studies are arranged to meet the needs of the individual. Students wishing to take this course will elect, with the advice of the instructors in charge, six hours per week of chemical work during the junior year, and seven hours per week during the senior year.

COURSE IN MECHANICAL ENGINEERING.

Mechanical engineering is concerned with the design, construction, care and operation of machinery.

The special studies are mathematical, including a large amount of drawing; technical, pertaining directly to the professional work of the engineer; and general.

The study of the scientific principles underlying the work of the engineer is accompanied throughout the course by actual practice in mechanical operations and scientific research, by training in the use of tools for working wood and metals, and by experimental tests and demonstrations in the mechanical, chemical and physical laboratories.

ELECTRICAL ENGINEERING COURSE.

The electrical engineering course is intended to meet the demands of a young man fitting himself for practical and professional engineering, in connection with the various applications of electricity.

By means of lectures, recitations and laboratory work, the subjects of the course are brought to the attention of the stu-

dent in such a manner as to emphasize not only the present needs of the practitioner and engineer, but to give him the groundwork that will enable him to grasp and understand the constantly increasing number of problems that require solution.

The instruction aims to impart a complete practical and theoretical knowledge of the best modern types of electrical machines and appliances and the methods of designing, building and operating them.

The rapid progress in recent years in applying electricity to commercial uses, renders it difficult, if not impossible, for one without a technical education to gain prominence in the work and be intrusted with its more responsible positions.

COURSE IN CHEMICAL ENGINEERING.

This course is intended to fit for the career of a professional chemist or chemical engineer, and to give a good foundation for original and independent chemical research.

Instruction is imparted by lectures, recitations and a large amount of carefully supervised laboratory work. The laboratory course is largely an individual one, and the work of each student is conducted with reference not only to the particular object he may have in view, but also to the acquirement of a broad knowledge of chemical science. The student is given a thorough training in German and French to enable him to read with ease the chemical literature; a thorough grounding in mathematics, necessary for advanced theoretical chemistry or chemical engineering; a somewhat limited amount of special engineering work, both mechanical and electrical; and a thorough undergraduate training in theoretical and applied chemistry. He is encouraged to develop the power of solving chemical problems by independent thought through the aid of the reference works and chemical periodicals which the library contains. Owing to the fact that the laboratories are becoming crowded the number of students taking this course is limited to six in each class. These six are chosen in the early part of the sophomore year from those who have applied. Fitness to become successful chemists will alone determine the choice made.

GENERAL COURSE.

The General Course is arranged for those who wish a broad general training based chiefly upon the study of science, modern languages and history. This course provides a liberal education with science as a leading element, and by means of the group

system of elective studies affords an opportunity for specialization.

COURSES FOR WOMEN.

Women attending the college may elect any course laid down in the curriculum, subject to the conditions prescribed for all students. They may omit manual labor on the farm and in the shop, and substitute other studies.

The general course, with its electives, is specially prepared for women, and is so planned that special courses may be arranged in literature, languages, history, philosophy, pedagogy, drawing, biology and manual training.

The courses in agriculture and chemistry afford opportunities for the study of the natural sciences, and the engineering courses offer exceptional advantages in mathematics and physics.

REQUIREMENTS FOR ADMISSION TO FOUR YEAR COURSES.

All candidates for admission to college must present satisfactory testimonials of good moral character.

Candidates for admission to the freshman class must offer studies amounting to a total of 14 units.

AGRICULTURAL COURSE.

Candidates for admission who intend to take the Agricultural Course must offer ten and one-half units from required subjects and three and one-half units from optional subjects, according to the following statement:

Required Group	A (English)	3	units
	B (American History or Ancient History)	1	unit
	C....(Algebra and Plane Geometry)	2½	units
	D............(Physics and Biology)	2	units
	E..............(French or German)	2	units
		10½	units
	(Optional)	3½	units
Total		14	units

ENGINEERING COURSES.

Candidates for admission who intend to take the Engineering Courses must offer ten units from required subjects and four units from optional subjects, according to the following statement. Beginning with Sept. 1910, Plane Trigonometry will be added to the required subjects.

Required Group	A (English)	3	units
	B (American History or Ancient History)	1	unit
	C (Algebra, Plane and Solid Geomtry)	3	units
	D. (Physics)	1	unit
	E. (French or German)	2	units
		10	units
	(Optional)	4	units
Total		14	units

GENERAL COURSE.

Candidates for admission who intend to take the General Course must offer ten and one-half units from required subjects and three and one-half units from optional subjects, according to the following statement:

Required Group	A (English)	3	units
	B (American History and Ancient History)	2	units
	C. (Algebra and Plane Geometry)	2½	units
	D. (Physics)	1	unit
	E. (French or German)	2	units
		10½	units
	(Optional)	3½	units
Total		14	units

GROUP A, ENGLISH.

The New England College Entrance Requirements in reading and study or any course of equivalent value—four periods per week for four years. Emphasis should be placed upon the development of a clear, correct style on the part of the candidate rather than upon the critical analysis of literature.

FOR 1909-1911.

Required for Study and Practice.

Shakespeare: Macbeth. Milton: Lycidas, Comus, L'Allegro, and Il Penseroso. Burke: Speech on Conciliation with America; *or* Washington: Farewell Address, and Webster: First Bunker Hill Oration. Macaulay: Life of Johnson; *or* Carlyle: Essay on Burns.

Required for Reading.

Group 1 (two books to be selected). Shakespeare: As You Like It, Henry V, Julius Cæsar, The Merchant of Venice, Twelfth Night.

Group 2 (one book to be selected). Bacon: Essays. Bunyan: The Pilgrim's Progress, Part I. The Sir Roger de Coverley Papers in "The Spectator." Franklin: Autobiography.

Group 3 (one book to be selected). Chaucer: Prologue. Spenser: Selections from the Faerie Queen. Pope: The Rape of the Lock. Goldsmith: The Deserted Village. Palgrave: Golden Treasury (First Series), Books II and III, with especial attention to Dryden, Collins, Gray, Cowper, and Burns.

Group 4 (two books to be selected). Goldsmith: The Vicar of Wakefield. Scott: Ivanhoe, Quentin Durward. Hawthorne: The House of the Seven Gables. Thackeray: Henry Esmond. Gaskell: Cranford. Dickens: A Tale of Two Cities. George Eliot: Silas Marner. Blackmore: Lorna Doone.

Group 5 (two books to be selected). Irving: Sketch Book. Lamb: Essays of Elia. De Quincey: Joan of Arc and The English Mail-Coach. Carlyle: Heroes and Hero-Worship. Emerson: Essays (selected). Ruskin: Sesame and Lilies.

Group 6 (two books to be selected). Coleridge: The Ancient Mariner. Scott: The Lady of the Lake. Byron: Mazeppa and the Prisoner of Chillon. Palgrave: Golden Treasury (First Series), Book VI, with special attention to Wordsworth, Keats, and Shelley. Macaulay: Lays of Ancient Rome. Poe: Poems. Lowell: The Vision of Sir Launfal. Arnold: Sohrab and Rustum. Longfellow: The Courtship of Miles Standish. Tennyson: Gareth and Lynette, Lancelot and Elaine, and The Passing of Arthur. Browning: Cavalier Tunes, The Lost Leader, How They Brought the Good News from Ghent to Aix, Evelyn Hope, Home Thoughts from Abroad, Home Thoughts from the Sea, Incident of the French Camp, The Boy and the Angel, One Word More, Hervé Riel, Pheidippides.

GROUP B, HISTORY.

The work offered for each unit in History must consist of at least five exercises per week during one year of the high school course, except that in the case of American History four exercises per week will be accepted. For details of preparatory work in History, reference is made to "A History Syllabus for Secondary Schools, by the New England History Teachers' Association." Boston, D. C. Heath & Co., 1904.

American History and Civics.

The History requirements are covered by Channing's Students' History, Montgomery's Students' History or by Hart's Essentials, with the collateral work. The work in Civics must include at least a knowledge of the Constitution of the United States.

—1 unit.

Ancient History.

Wolfson's Essentials or an equivalent, with the collateral work, or, the History of Greece and the History of Rome as given in works like Myers' History of Greece, Morey's Outlines of Greek History, Allen's Roman People, Myers' Rome and Morey's Outlines of Roman History. The requirements are limited to Grecian History and Roman History to A. D. 476.

—1 unit.

English History.

The amount of English History required is represented by Gardiner's Students' History, by Larned's or Montgomery's History, or by Walker's Essentials, with the collateral work.

—1 unit.

Mediaeval and Modern History.

Harding's Essentials of Mediæval and Modern History with the collateral work, or Myers' Mediæval and Modern History, or an equivalent.

—1 unit.

GROUP C, MATHEMATICS.

Algebra.

Through quadratic equations, including radicals and fractional and negative exponents, binomial theorem and progressions,—five periods per week for one and one-half years.

—1½ units.

Plane Geometry.

The equivalent of Wells' presentation.

—1 unit.

Solid Geometry.

The equivalent of Wells' presentation.

—½ unit.

Plane Trigonometry.

The equivalent of Wells' presentation.

—½ unit.

GROUP D, SCIENCE.

Accompanying the certificates for each of the sciences the student MUST present at entrance a note-book containing records and drawings of his or her observations and experiments in the laboratory, which must bear the certificate of the teacher in charge that the work was done personally in the laboratory.

Physics.

The preparation required for entrance in Physics shall be an equivalent of five exercises a week for one year, of which at least two are devoted to laboratory work.

—1 unit.

Biology.

Students in the Agricultural Course must present either.

A. Zoology.

Kellogg's Elementary Zoology, Linville and Kelly's Text book in General Zoology. Jordan, Kellogg and Heath's Animals, Needham's Lessons in Zoology, Coulton's Zoology, or an approved equivalent, occupying at least four periods per week for a half year, of which at least one is devoted to laboratory work.

—½ unit.

and Botany.

Bergen's Elements of Botany, or an approved equivalent, occupying at least four periods per week for a half year, of which at least one is devoted to laboratory work.

—½ unit.

or

B. Botany.

Coulter's Text Book of Botany, Bergen's Foundations of Botany, or an approved equivalent, occupying at least four periods per week for one year, of which at least one is devoted to laboratory work.

—1 unit.

Geology.

Leconte's Compend or an approved equivalent.

—½ unit.

Chemistry.

Elementary Inorganic Chemistry equivalent to the work covered in Remsen's Briefer Course, Storer & Lindsay's Manual, Witham's Elements or Newell's Descriptive Chemistry, accompanied in each instance with laboratory practice.

—1 unit.

GROUP E, MODERN LANGUAGES.

French.

Two years are required for preparation in French. Work of the first year should include (1) careful drill in pronunciation, (2) drill upon the rudiments of grammar, (3) abundant translation of simple English prose into idiomatic French, (4) reading of from 100 to 175 pages of French prose, (5) writing French from dictation. Work of the second year should include (1) the reading of from 250 to 400 pages of easy modern prose, (2) constant practice in translating from English into French variations of the text read, (3) frequent paraphrases of the text read, (4) dictation.

—2 units.

German.

Two years are required for preparation in German. Work of the first year should include (1) careful drill in pronunciation, (2) drill upon the rudiments of grammar, such as the inflection of the articles, the common nouns, adjectives, pronouns and strong and weak verbs, upon the uses of the prepositions, the modal auxiliaries and the rules of syntax and word order, (3) writing from dictation, (4) the reading of from 75 to 100 pages of prose, (5) translation from English into German. Work of

the second year should include (1) the reading of from 150 to 200 pages of prose, (2) constant practice in translating from English into French variations of the text read, (3) dictation, (4) continued drill upon the rudiments of grammar, (5) frequent paraphrases of the text read.

—2 units.

GROUP F, ANCIENT LANGUAGES.

Students entering from approved schools may receive credit in their certificates for the following work in Latin or Greek.

Latin.

Grammar and four books of Cæsar. Two year's work.

—2 units.

Vergil, six books.
Cicero, six orations.

—2 units.

Greek.

Books I and II of Xenophon's Anabasis, Books III and IV of the Anabasis or their equivalent in other Attic prose, and 1,500 lines of Homer.

—2 units.

CERTIFICATES.

In place of examinations, certificates will be received from approved preparatory schools, including all that have been approved by the superintendent of public instruction in New Hampshire. Approval of a school will be withdrawn whenever it appears that the work of the school does not reach the standard required by the college. No certificate will be accepted from a private tutor or instructor.

Certificates should meet the requirements IN FULL; in case of exceptions the candidate will be examined on any requirement not covered by the certificate. If the certificate makes ANY exception in the case of a student who has not regularly graduated from an approved school, the certificate will not be accepted, and the student will be examined on all the requirements.

Certificates will be accepted for that work only which has been done in the certifying school, or which is necessarily involved in the work done there; work done in the grammar school must not be certified unless reviewed in the high school.

Certificates must be made out on a blank furnished by the college, and should be mailed to the dean at the CLOSE of the SCHOOL year.

COMPLETE CERTIFICATES.

THE SIGNATURE OF THE PRINCIPAL IS TO BE AFFIXED TO THE GENERAL CERTIFICATE, AND TO THAT OF EACH DEPARTMENT IN WHICH THE WORK OF THE CANDIDATE IS CERTIFIED.

PARTIAL CERTIFICATES.

In case the work of a graduate has not been up to certificate grade in one or more subjects, the principal is requested to sign the general certificate, crossing out the words "and that in my judgment he is prepared to enter at once upon the work of the freshman year." He is also requested to fill out the group certificates in full *except signature*, the signature being attached only to such as indicate certificate grade.

Divided certificates from two or more schools will be accepted when the preparatory work has been done in more than one institution.

Certificate forms will be furnished upon application.

Candidates for advanced standing are also examined in the studies that have been pursued by the class which they propose to enter.

Examinations will be given, in the subjects presented for admission, beginning Friday of the week preceding the opening of the college year. Candidates will present themselves with their credentials on the first day of the examinations. See Calendar.

REQUIREMENTS FOR GRADUATION FROM FOUR YEAR COURSES.

Those who complete a four year course or its equivalent will be recommended for the degree of Bachelor of Science. No equivalent course will be accepted which does not comply with all the following requirements:

1. The completion of all work common to the four year courses.
2. The completion of one hundred fifty-four credit hours.
3. The completion of all but ten or less credit hours in some one of the regular four year courses.

4. Approval by the faculty not earlier than June 1 preceding the year of graduation.

The regular work of the senior class, including the regular final examinations, is completed at 4 p. m. on the Tuesday of the week preceding commencement; and each member of the class may receive a statement of his standing at the office of the registrar at 2 p. m. on the next day, Wednesday.

All work required for graduation must be completed by 6 p. m. of the Saturday of the same week.

THESIS.

A thesis upon some subject connected with the work of the course taken is required of every candidate for a degree. The subject together with a written approval of it by the head of the department within which it lies must be submitted to the president before the 15th day of December preceding graduation. The thesis shall be submitted to the head of the department concerned not later than the second Tuesday preceding commencement day. The thesis must be completed in typewritten and bound form and be in the hands of the department concerned before the Tuesday preceding commencement day. The thesis shall be typewritten or printed upon standard thesis paper eight and one-half by eleven inches, medium weight, neatly bound in black cloth and gilt-lettered on first cover with title, name of author, degree sought and year of graduation. This bound copy shall be filed and left with the college librarian.

FOUR YEAR COURSES.

DESCRIPTION OF STUDIES.

AGRONOMY.

PROF. TAYLOR, MR. EASTMAN.

1. Farm Equipment and Farm Crops.

Lectures and recitations upon the selection, planning and equipment of farms; fencing; drainage; farm wells; harvesting and tillage implements; silos and stable construction, etc. History, use and methods of culture of our various farm crops. Practical exercises in leveling and laying out of drains and in the preparation of farm and building plans. Judging and scoring the different varieties of grains and grasses. For Agricultural Juniors.

Three exercises per week. 1st S.

2. **Soils and Soil Physics.**

Lectures and recitations upon the formation, kinds and physical properties of soils; the movements and conservation of soil moisture; the relation of heat and air to soil; the nature and physical effects of tillage and fertilizers; laboratory work and experimentation with soils to show the physical effects of different conditions and texture. For Agricultural Juniors.

Three exercises per week. 2nd S.

3. **Soil Management and Fertility.**

An advanced course in soils for those who have shown a special aptitude in the preceding course. The processes of soil formation, the physics and chemistry of soils, soil classification and mapping and the principles of fertility will be discussed. The lecture work will be supplemented by laboratory and field experimentation. Elective for Agricultural Seniors.

Three exercises per week. 1st S.

4. **Manures and Fertilizers.** Prof. Morse.

course of lectures, themes and abstracts on the subject of plant food and its sources. Elective for Agricultural Seniors.

Two exericses per week. 2nd S.

5. **Agricultural Seminary.** Prof. Taylor.

This course consists of library and reference work and a study of current agricultural literature. Each student will prepare during the term a certain number of abstracts, reports of papers upon topics relating to agriculture. For Agricultural Seniors.

Two exercises per week. 1st S.

6. **Agricultural History and Economics.** Prof. Taylor.

Lectures and recitations upon the history of agriculture from early Egyptian to modern American; present agricultural methods and systems in various countries; the principles of economics as applied to the organization, equipment and operation of the farm; tenancy and land ownership; practical problems in farm management. For Agricultural Seniors. First nine weeks.

Four exericses per week. 2nd S.

7. **Farm Mechanics.** Prof. Taylor.

Lectures and recitations upon the principles of construction of farm buildings; barns and silos; construction and maintenance of country roads; principles of draft; farm motors and machinery.

Practical work in testing and comparisons of various makes and kinds of farm machinery. For Agricultural Seniors. Last eight weeks.

Four exercises per week. 2nd S.

ANIMAL HUSBANDRY.

ASSOC. PROF. PEW, MR. MCNUTT.

1. Breeds of Livestock.

Lectures and recitations upon the origin, history, development, characteristics and adaptability of the different breeds of cattle, sheep, horses and swine. In the study of beef cattle, market conditions and requirements are considered. In the study of dairy cattle, milk and butter production are considered. In the study of sheep, mutton and wool requirements are considered, also the raising of early lambs.

In the study of horses, besides the origin, history and development of the breeds, market classifications are considered. In the study of swine, the influence of various feeds and of different methods of management as affecting types is considered. One afternoon each week is used for judging the different breeds. For Agricultural Sophomores.

Three exercises per week. 1st S.

2. Principles of Breeding.

Lectures and recitations upon the laws of heredity; value of selection in improving and maintaining a high standard of excellence in farm stock; variation, cause and extent; methods of breeding, including discussion of inbreeding, crossing and grading. Elective for Agricultural Seniors.

Two exercises per week. 2nd S.

3. Stock Feeding.

Lectures and recitations upon the laws of nutrition; composition and digestibility of feed stuffs; influence of feed on the animal body, preservation of coarse fodders; a study of leading cereals and by-products. Practice will be given in computing and compounding rations for various purposes. For Agricultural Juniors.

Three exercises per week. 2nd S.

4. Veterinary Science.

Lectures and recitations upon anatomy and physiology of the animal body; holding a post-mortem; simple farm medicines and

methods of administering; breeding and some of its effects; common farm operations; common infectious and contagious diseases affecting farm animals and methods of treatment. Elective for Agricultural Juniors.

Three exercises per week. 2nd S.

5. Poultry.

Lectures and recitations upon different classes and varieties of poultry; breeding and feeding; location and building of poultry houses; a study of incubators and brooders; methods of preventing disease. Practice will be given in scoring. Elective for Agricultural Seniors.

Two exercises per week. 2nd S.

6. Advanced Livestock.

This is a course laid out especially for those students who have shown proficiency in the previous courses having to do with Livestock. Special problems will be worked out as desired by the students concerning the breeds and their management; advanced live stock judging will also be given. Elective for Agricultural Juniors.

Three exercises per week. 2nd S.

7. Animal Mechanics.

Lectures and recitations upon the conformation, soundness and anatomy of the horse, the principles of mechanics involved as applied to the animal machine, proportions and conformation of horses for speed and draft; various gaits; practical exercises in measuring animals and testing value of given measurements for given purposes. Course to be given every other year beginning with 1905. Elective for Agricultural Seniors or Juniors.

Four exercises per week. 1st S.

BOTANY.

PROF. BROOKS, MR. LEWIS.

1. General Botany. Prof. Brooks, Mr. Lewis.

Lectures and laboratory work on the fundamental principles of plant physiology, followed by the study of a series of representative cryptogams. For Agricultural Sophomores, elective for General Course Sophomores.

Three exercises per week. 1st S.

2. General Botany. Prof. Brooks, Mr. Lewis.

This course continues the work on type forms begun in Course 1 and includes the study of vascular cryptogams, gymnosperms and angiosperms. The latter part of the semester will be devoted to a study of plant families and plant societies as represented in the local flora. Lectures, laboratory and field work. For Agricultural Sophomores, elective for General Course Sophomores.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

3. Plant Pathology. Prof. Brooks.

This course deals with the nature, cause and prevention of plant diseases and includes a systematic consideration of parasitic fungi. Lectures and laboratory work. Elective for Agricultural Juniors and General Course Juniors and Seniors.

Open only to students who have completed Course 2.

Four exercises per week. 1st S.

4. Mycology. Prof. Brooks.

A study of representative groups of fungi, including the bacteria; culture methods and pathological work with fungous diseases. Lectures, laboratory and field work. Elective for Agricultural Juniors and General Course Juniors and Seniors.

Open only to students who have completed Course 2.

Three exercises per week. 2nd S.

5. Plant Physiology. Prof. Brooks, Mr. Lewis.

Lectures and experimental work on absorption, nutrition, growth, respiration and irritability. Elective for Agricultural Juniors and General Course Juniors and Seniors.

Open only to students who have completed Course 2.

Three exercises per week. 2nd S.

6. Plant Histology. Mr. Lewis.

A minute study of plant cells and plant tissues, starches, aleurones and other cell contents; use of reagents and stains; cutting and mounting of sections. Lectures and laboratory work. Elective for General Course Juniors and Seniors and Agricultural Seniors.

Open only to students who have completed Course 2.

Three exercises per week. 1st S

7. 8. Advanced Botany. Prof. Brooks, Mr. Lewis.

Opportunity to do original work along special lines will be offered to students who have shown special ability in the preceding courses.

Three exercises per week throughout the year.

CHEMISTRY.

ORGANIC CHEMISTRY—PROF. MORSE.

INORGANIC CHEMISTRY—PROF. PARSONS,

ASST. PROF. JAMES, DR. RANDALL.

1. Inorganic Chemistry.

Lectures and recitations on general and theoretical chemistry, illustrated by experiments, charts, specimens, lantern views, etc. Solution of chemical problems will be required. For all Freshmen.

Three exercises per week. 1st S.

2. Inorganic Chemistry.

Course 2 is a continuation of Course 1, but the time will be mainly spent on the metallic elements, their metallurgy, salts, etc.

Open only to students who have completed Course 1.

Two exercises per week. 2nd S.

3. Elementary Physical Chemistry.

A short elementary course of ten lectures on the Dissociation Theory and its application; the Mass Law, etc. To accompany Courses 2 and 4.

Elective by special arrangement.

4. Qualitative Analysis.

Course 4 consists of laboratory practice, with occasional lectures. The student is expected to become proficient in the separation and detection of the common acids and bases and to keep a full set of notes. He will have practice in the writing of reactions and will fill out numerous slips containing questions bearing upon his work. For Chemical Freshman, Electrical and Mechanical Freshmen (Division 1), Agricultural Sophomores and Electrical and Mechanical Sophomores (Division 2); elective for General Course Sophomores and Juniors.

Open only to students who have completed Course 1.

Freshman Year. 2nd S.

Sophomore and Junior Years. 1st S.

Fifty-one exercises.

5. Qualitative Analysis.

A short advanced course for Chemical Sophomores on insoluble substances and the rarer elements, to precede Chemistry 10. First five weeks.

Twenty-five exercises. 1st S.

6. Organic Chemistry. Prof. Morse.

Lectures and recitations. A study of the chemistry of the carbon compounds. For Agricultural and Chemical Sophomores, elective for General Course Juniors.

Open only to students who have completed Chemistry 1 and 2.

Three exercises per week. 2nd S.

7. Chemistry of Plant and Animal Nutrition. Mr. Morse.

Lectures and recitations on the composition of plants, animals and foods. For Agricultural and Chemical Juniors, elective for General Course Seniors.

Open only to students who have completed Chemistry 6.

Two exercises per week. 1st S.

8. Organic Chemical Laboratory. Prof. Morse.

The course consists mainly of laboratory practice in preparing and purifying organic compounds and a study of qualitative organic reactions and analyses. Lectures and recitations will be held from time to time in connection with the practice. For Chemical Juniors, elective for General Course Juniors.

Three exercises per week. 1st S.

10. Quantitative Analysis.

A preliminary course in quantitative analysis to familiarize the student with the general methods of chemical manipulation and analysis. For Chemical Sophomores. Elective in the General Course in Sophomore, Junior and Senior Years, provided laboratory facilities permit. Last twelve weeks.

Open only to students who have completed Chemistry 4.

Five exercises per week. 1st S.

11. Quantitative Analysis.

A continuation of Course 10. For Chemical Sophomores.

Six exercises per week. 2nd S.

12. Advanced Quantitative Analysis.

Course 12 is arranged for students of the Chemical Courses, and is intended to fit them for work in the laboratories of agri-

cultural experiment stations, fertilizer works, iron works, sugar refineries, etc., and for the duties of the public analyst. This course will be made to fit the end which each has in view, and will be largely an individual one. For those students desiring to specialize in agricultural and food chemistry the analysis made will tend in the main toward agricultural products, fertilizers, mucks, marls, manures, dairy products, waters, foodstuffs, sugars, etc. For the student wishing to enter metallurgical works, the analyses will be in the main upon iron and steel and other metals, ores, limestones, slags, alloys, fuels, etc. As a preparation for the study of medicine, work will be done on poisons, foods, drugs, urine, etc. Other lines will be arranged to meet the wants of the individual student. Each student will be given some practice in all of the branches of agricultural, metallurgical, medical, sanitary and industrial chemistry, in order to lay a foundation for any future work which may be required of him. A short course in gas and oil analysis will also be provided. For Chemical Juniors.

Open only to students who have completed Course 11.

Five exercises per week. 1st S.

13. Advanced Quantitative Analysis.

A continuation of Course 12. For Chemical Juniors.

Four exercises per week. 2nd S.

14. Industrial Chemistry.

Course 14 consists of lectures on chemical manufactures, such as sugar, sodium carbonate, fertilizers, sulphuric acid, glass, matches, paints, dyes, soaps, illuminating gas, petroleum, etc. The lectures will be illustrated by lantern views, and trips to the leading New England cities to examine important chemical manufactures will be taken as far as practicable. For Chemical Juniors and Seniors.

Open only to students who have completed Courses 1 and 2.

Two exercises per week. 2nd S.

15. Metallurgy.

Course 15 consists of lectures describing the processes employed in the smelting of ores of iron, lead, copper, zinc, silver, gold, etc., and upon the methods used in refining these metals. The lectures are illustrated by stereopticon and by specimens of metallurgical products. For Chemical Juniors or Seniors.

Open only to students who have completed Courses 1 and 2.

One exercise per week. 2nd S.

Courses 14 and 15 are given in alternate years with Course 22.

16. **Assaying.**

A course in the fire assay of gold and silver ores. For Chemical Seniors.

Open only to students who have taken Courses 10 or 18.

Seventeen exercises. 1st S.

17. **Agricultural Analysis.**

This course is arranged especially for students of the agricultural course, and consists mainly of the quantitative determination of the constituents of milk, butter, fertilizers, grain, etc. Elective, subject to desk room in laboratory.

Open only to students who have completed creditably the work of Courses 1, 2, and 4.

Three exercises per week.

18. **Metallurgical Analysis.**

This course is arranged for the students of the engineering departments who may elect the same, and consists mainly of the quantitative determination of ores, slags, metals, alloys, fuels, etc. Elective, subject to desk room in the laboratory.

Open only to students who have completed creditably the work of Courses 1, 2, and 4 or 5.

Three exercises per week.

19. **Chemical Journals, Methods, etc.**

The work consists of the study of current chemical literature, mainly in the German language, with recitations twice a week. Each student will be expected to prepare abstracts, reports, criticisms, etc., upon assigned articles. For Chemical Juniors.

Open to students who have begun Course 11.

Two exercises per week. 1st S.

20. **Chemical Journals.**

A continuation of Course 19. For Chemical Juniors.

Two exercises per week. 2nd S.

21. **Physical Chemistry, Lectures.**

The work consists of advanced study of chemical theory. Practical experiments will be performed, with the aid of the student, in the determination of vapor density, molecular weights, specific heat, etc.; and the study of isomorphism, diffusion of gases, solutions, ionization, electrolysis, molecular and atomic volume, thermo chemistry, equilibrium, the phase rule, etc., will take up

much of the time. For Chemical Juniors and Seniors. Course 21 comes in alternate years.

Open only to students who have completed Courses 1, 2 and 10.

Two exercises per week. 1st S.

22. Physical and Electro Chemistry, Lectures.

A continuation of Course 21, and is given in alternate years with Courses 14 and 15. For Chemical Juniors or Seniors.

Three exercises per week. 2nd S.

23. Chemical Research.

Especially arranged for students of the chemical engineering course. May merge at any time into 24 and will usually do so about the middle of the first semester. For Chemical Seniors.

Eight exercises per week. 1st S.

24. Thesis.

The work of the last semester of the chemical engineering course is given up to the special study of some selected subject in any branch of chemical science and the student is required to present a thesis showing him to be capable of independence of thought and manipulation. For Chemical Seniors.

Eight exercises per week. 2nd S.

DAIRYING.

ASSOC. PROF. RASMUSSEN.

1. Farm Dairying.

Lectures and recitations on the Babcock test, tests for determining acidity in milk and on the use of the lactometer in detecting adulterations in milk. Includes also a study of the composition of milk, separation and churning. The laboratory work will be made applicable to farm conditions. For Agricultural Juniors.

Four exercises per week. 1st S.

2. Advanced Butter Making.

A study of the secretion, chemical and physical properties of milk, pasteurization, cream ripening, commercial starters, churning, marketing and scoring of butter. The laboratory work will be made applicable to factory conditions.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

3. Technology of Milk.

Consists of a study of the uses of milk and its by-products outside the scope of butter and cheese making; the production and preparation of sanitary, certified, modified milk; the making of condensed milk and koumiss; the manufacture of casein and milk sugar, and the preparation of ices and ice cream. Elective for Agricultural Juniors and Seniors.

Open only to students who have completed Course 1.

Two exercises per week. 2nd S.

4. Factory Management.

This course is designed for students wishing to fit themselves for managers of large factories and other dairy establishments. It consists of a study of the organization, location, construction, and operation of factories; special problems connected with the manufacturing of butter; dairy conditions and methods in foreign countries.

Open only to students who have completed Course 2.

Three exercises per week. 1st S.

5. Dairy Bacteriology and Cheese Making.

Lectures and demonstrations on the function of bacteria and the application of bacteriological principles to dairy work.

A course of lectures will be given covering the details of the manufacturing, curing and marketing of the more important kinds of cheese.

Open only to students who have completed Course 1.

Two exercises per week. 2nd S.

6. Dairy Research.

A study of the work of the experiment stations and other dairy literature. Elective for Agricultural Seniors.

Open only to students who have completed Courses 1, 2 or 3.

Two exercises per week. 1st S.

DRAWING.

PROF. PUTNAM, MR. LATON.

These courses are of an industrial nature and include both freehand and mathematical branches of this subject.

1. Industrial Drawing. Prof. Putnam, Mr. Laton.

Free-hand lettering, free-hand drawing, use of instruments, mathematical drawing, inking, tinting, tracing and blue-prints.

Systems of object drawing; orthographic projection; isometric drawing; mechanical perspective, shades and shadows. For Ag-

ricultural and Engineering Freshmen, elective for General Course Freshmen.

Agricultural and General Course Freshmen.

Two exercises per week. 1st S.

Engineering Freshmen.

Two and one-half exercises per week. 1st S.

NOTE.—Alternating with shop-work on Wednesdays.

2. **Descriptive Geometry.** Prof. Putnam, Mr. Laton.

Recitations and drawing exercises in the solution of geometrical problems by orthographic projection.

For Engineering Freshmen. (Divisions 1 and 2.)

Division 1, whole semester.

Three exercises per week. 2nd S.

Division 2, first ten weeks.

Two exercises per week. 2nd S.

3. **Descriptive Geometry.** Prof. Putnam, Mr. Laton.

Continuation of 2. Practical problems on bridge beams, rafters, piping, etc.

For Engineering Freshmen (Division 2). Last seven weeks.

Two exercises per week. 2nd S.

4. **Design of Farm Buildings.** Prof. Putnam.

This course consists of drawings of floor plans and framing details for farm buildings in preparation for the Rural Architectural Course of the Senior Year. For Agricultural Freshmen.

Two exercises per week. 2nd S.

5. **Descriptive Geometry.** Prof. Putnam, Mr. Laton.

Same as Course 3. For Electrical and Mechanical Sophomores (Division 1). First seven weeks.

Two and one-half exercises per week. 1st S.

6. **Elementary Machine Drawing.** Mr. Laton.

Mechanism drawing; detail and assembly drawing of simple machines. For Electrical and Mechanical Sophomores.

Division 1, last ten weeks.

Two exercises per week. 1st S.

Division 2, whole semester.

Two exercises per week. 1st S.

7. Elementary Machine Drawing and Free Hand Drawing of Chemical Apparatus. Mr. Laton.

For Chemical Sophomores.

Two exercises per week. 1st S.

8. Machine Drawing. Mr. Laton.

Working drawings of various machines and machine tools including steam boiler and engine details. For Electrical and Mechanical Sophomores.

Two and one-half exercises per week. 2nd S.

NOTE.—Alternating with shop-work on Wednesdays.

9. Free-Hand Drawing. Prof. Putnam.

Light and shade drawing from casts and still life. Charcoal work. Elective for General Course Sophomores.

Two exercises per week. 1st S.

10. Free-Hand Drawing.

Wash drawings and water color work; pencil sketching from nature and exercises in perspective. Elective for General Course Sophomores.

Two exercises per week. 2nd S.

11. Architectural Drawing.

Studies of architectural detail and historic ornament. Elective for General Course Juniors.

Three exercises per week. 1st S.

12. Architectural Drawing.

Continuation of 11. The design of a building with details of ornament. Elective for General Course Juniors.

Three exercises per week. 2nd S.

13. Advanced Architectural Drawing.

Elective for General Course Seniors.

Open only to students who have completed Courses 11 and 12.

Three exercises per week. 1st S.

14. Advanced Architectural Drawing.

Elective for General Course Seniors.

Open only to students who have completed Courses 11, 12 and 13.

Two exercises per week. 2nd S.

16. Free-hand or Charcoal Drawing.

Elective for General Course Freshmen. Last seven weeks.

Four exercises per week. 2nd S.

ELECTRICAL ENGINEERING.

PROF. HEWITT, ASST. PROF. BUCK.

1. Dynamo Electric Machinery.

The course begins with a general study of both direct and alternating current dynamos and motors, including elementary theory, with a large number of practical problems to illustrate application of same. For Electrical and Mechanical Juniors.

Open only to students who have completed Physics 2 and Mathematics 6.

Three exercises per week. 1st S.

2. Dynamo Electric Machinery.

This course is a continuation of Course 1. It takes up the theory of armature winding and construction; the general points of design; a study of various types of electrical machinery; laboratory methods of measurements, the various electrical quantities such as electric motive force, current, resistance, permeability of iron, the use of standard instruments; the laws of electrolysis; thermo-electric currents, etc. For Electrical and Mechanical Juniors.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

4. Electrical Laboratory.

This course consists of the measurement of resistances, inductances, the calibration of a ballistic galvanometer and Ryan electrometer, the permeabilities of samples of iron. Tests are made to determine the characteristic curves, efficiency curves, etc. The determination of the candle power of incandescent and arc lamps, the calibration of resistances, the measurement of power in alternating current circuits, alternator characteristics, the testing of synchro-

nous and polyphase motors, transformers, power measurements by wattmeters and a general study of polyphase machinery constitute the remainder of the course. For Electrical Juniors.

Open only to students who have completed Course 1.

Two exercises per week. 2nd S.

6. Telegraph and Telephone.

This course consists in a careful study of the elementary electrical principles of telegraphy; the construction and connection of lines, repeaters; high speed telegraphy; simple and multiplex telegraphy; submarine signalling; automatic devices, general electric signalling for purposes of alarms, railroads, etc., and wireless telegraphy; also a course of lectures and recitations on the acoustic and electrical principles of telephony; the different forms of calling and receiving apparatus and accessories and simple circuits. The last part of the course is devoted to the consideration of the more complex forms of circuits, exchange switchboards, transfer systems and the construction of overhead and underground systems. For Electrical Juniors.

One exercise per week. 2nd S.

11. Electrical Engineering Practice.

This course takes up the study of the properties of periodic curves; the effects of self-induction and capacity and a more detailed study of dynamos, motors, transformers and other electrical apparatus. For Electrical Seniors.

Open only to students who have completed Course 2.

Three exercises per week. 1st S.

12. Electrical Engineering Practice.

This course is a continuation and completion of Course 11. It takes up more advanced theory and general practice. It also includes a thorough study of High Tension Power Transmission and deals with the selection of apparatus for generating stations and the distributing systems. A study will be made of the proper combinations of apparatus to correctly represent standard theory and practice. The design of the transmission line and of the distributing systems will be considered. The application of the theory will be brought out in lectures and established with a large number of practical problems. A careful study will be

given to the various methods used for lightning protection. For Electrical Seniors.

Open only to students who have completed Course 11.

Four exercises per week. 2nd S.

13. Electric Railways.

In this course will be considered the principles which govern the application of electric motors to railway service, and the location of power and sub-stations as determined by economic questions. Following this will be given the practical points involved in the selection and operation of railway equipment including power and sub-station equipment, line and track, railway motors and car equipment, storage batteries, etc. The problem of utilizing electric energy in mining will also be considered. For Electrical Seniors.

Open only to students who have completed Course 2.

Two exercises per week. 1st S.

15. Electrical Laboratory.

This course is a continuation of Course 4 covering a more advanced series of experiments. A written report will be required for which one additional credit hour will be given. For Electrical Seniors.

Open only to students who have completed Course 4.

Four exercises per week. 1st S.

16. Electrical Laboratory.

This course is a continuation of Course 15 and takes up experiments of a more advanced nature. A written report will be required for which one additional credit hour will be given. For Electrical Seniors.

Open only to students who have completed Course 15.

Three exercises per week. 2nd S.

17. Electrical Laboratory.

This course is similar to Course 4 only a specially arranged series of experiments is provided adapted to the needs of students in the Mechanical Engineering Course. A written report will be required for which one additional credit hour will be given. For Mechanical Seniors.

Open only to students who have completed Course 2.

Two exercises per week. 1st S.

18. Thesis.

A deposit of fifteen dollars to cover any damage done to instruments or apparatus, etc., is required in this course. Any unexpended balance is refunded at the close of the college year. Where apparatus is constructed as a part of a thesis, it shall remain the property of the department. For Electrical Seniors.

Three exercises per week. 2nd S.

19. Dynamo Electric Machinery.

This course is a continuation of Course 2, but arranged to meet the requirements of students in Mechanical Engineering. This course is not as advanced as Course 11, but covers the same subjects in a more elementary manner. For Mechanical Seniors.

Open only to students who have completed Course 2.

Three exercises per week. 1st S.

20. Dynamo Electric Machinery.

This course is a completion of Course 19. For Mechanical Seniors.

Open only to students who have completed Course 19.

Two exercises per week. 2nd S.

21. Industrial Electricity.

This course consists of a careful study of the principles and methods employed in electrical measurements, such as resistance of wire and batteries, e. m. f. of cells, current measurement by ammeters and electrolysis, the use of electrical measuring instruments and a series of laboratory experiments specially arranged to meet the requirements of Chemical Engineers. A brief study will be made of the dynamo, motor, transformer, primary and secondary batteries, arc and incandescent lamps and the general principles of electrical distribution. Experiments in electrolysis, electrical furnaces, reduction of metals, etc. are provided. For Chemical Seniors.

Three exercises per week. 1st S.

22. Industrial Electricity.

This course is a continuation of Course 21, but more advanced in nature. For Chemical Seniors.

Open only to students who have completed Course 21.

Three exercises per week. 2nd S.

ENGLISH.

PROF. GROVES, MR. SPENCER.

1. **English Composition and Rhetoric.** Mr. Spencer.

The theory of composition, theme writing, book reviews and an introduction to the principles of literary criticism. For all Freshmen.

Three exercises per week. 1st S.

2. **English Composition and Rhetoric.** Mr. Spencer.

This is a continuation of Course 1.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

3. **Advanced English Composition and Criticism.** Mr. Spencer.

(a) Composition. The four forms of composition (narration, description, exposition and argumentation) will be taken up and practice given in each form. There will also be daily and weekly themes based on topics of the day, (editorials), and on required readings. (Gardner's Forms of Prose Literature.)

(b) Criticism. The history of criticism will be studied briefly, each student having one novel and one poet to criticise. (Winchester's Principles of Literary Criticism). Elective for General Course Sophomores and Juniors.

Three exercises per week. 1st S.

4. **The English Drama.** Mr. Spencer.

Lectures on the English drama, with required readings in Shakespeare, Sheridan and Goldsmith. There will also be recitations and discussions. Elective for General Course Juniors and Seniors.

Three exercises per week. 2nd S.

5. **The English Novel.** Prof. Groves.

A seminar study of the development of the English novel. Elective for General Course Juniors and Seniors after consultation with the instructor.

Three exercises per week. 1st S.

6. **English Literature.** Prof. Groves.

The historical development of English literature. This course is designed to set forth the philosophy of literature and the

relation of writers to their predecessors and contemporaries. Text books, lectures and readings. For Agricultural and Chemical Seniors and General Course Sophomores or Juniors.

Three exercises per week. 2nd S.

7. American Literature. Prof. Scott.

Lectures with an extensive course of reading. Elective for General Course and Agricultural Seniors.

Four exercises per week. 2nd S.

FORESTRY.

PROF. PICKETT.

1. Principles of Forestry.

This course is intended to give the student a knowledge of the various methods of forestry management in Europe and America. The text and lectures will cover the use of trees for shelter, shade and ornament, and their propagation; the value of trees for timber; how to improve existing woodlands; the influence of forests upon soils, crops and climate; the establishment and management of plantations and forest trees. For Agricultural Juniors.

Three exercises per week. 1st S.

2. Forest Technology.

This course aims to give the student advanced theoretical and practical work in establishing, improving and managing woodlands; in estimating and measuring standing timber and harvesting forest products; forest administration, laws and working plans. Seminary and laboratory work. Elective for Agricultural Seniors who have shown special ability in Course 1.

Three exercises per week. 1st S.

3. Systematic Arboriculture.

A study of the botanical and physical characters of forest trees and shrubs. Special stress is laid on the value of various trees for lumber, fuel, posts, etc. Rapidity of growth, denseness and strength of fiber, etc. are features given particular attention. Elective for Agricultural Juniors who wish to specialize in Forestry.

Three exercises per week. 1st S.

4. Forest Nursery Management.

A study of the methods of propagation and care of trees, shrubs, and perennial plants in the nursery. This course will be the same as Horticulture 10 except that students specializing in forestry will be given forest trees and shrubs for laboratory work instead of fruit and ornamental plants. Elective for Agricultural Juniors who wish to specialize in Forestry.

Three exercises per week. 2nd S

FRENCH.

PROF. WHORISKEY, MR. SPENCER.

1. Elementary French. Mr. Spencer.

Essentials of French grammar and reading, with practice in speaking and writing French. Dictation. For Freshmen offering German for admission.

Three exercises per week. 1st S.

2. Elementary French. Mr. Spencer.

Continuation of Course 1. Reading of Modern French Prose; translation from English into French of connected narrative. Dictation. For Freshmen offering German for admission.

Three exercises per week. 2nd S.

3. French Prose. Prof. Whoriskey.

Reading and translation of French Prose, Composition, Poems. Elective for General Course Juniors.

Three exercises per week. 1st S.

4. French Prose, History and Travel. Prof. Whoriskey.

Reading and Translation, Composition based on some book read in class. Elective for General Course Juniors.

Three exercises per week. 2nd S.

***5. French Prose of Nineteenth Century.** Prof. Whoriskey.

Selections from Hugo, Balzac, Sand, Dumas père, Daudet will be read. Sight reading. Elective for General Course Seniors.

Three exercises per week. 1st S.

***6. French Prose of Nineteenth Century.** Prof. Whoriskey.

Continuation of Course 5. Elective for General Course Seniors.

Three exercises per week. 2nd S.

*7. **French Literature in the Seventeenth Century.** Prof. Whoriskey.

Corneille, Racine, Molière, Bossuet, Mme. de Sévigné, La Fontaine. Elective for General Course Seniors.

Three exercises per week. 1st S.

*8. **French Literature in the Seventeenth Century.** Prof. Whoriskey.

Continuation of Course 7. Elective for General Course Seniors.

Three exercises per week. 2nd S.

9. **French Composition.** Prof. Whoriskey.

Elective for General Course Seniors.

One and one-half exercises per week. 1st S.

10. **French Composition.** Prof. Whoriskey.

Elective for General Course Seniors.

One and one-half exercises per week. 2nd S.

GEOLOGY.

PROF. PARSONS, MR. BARROWS.

1. **Mineralogy.** Prof. Parsons.

A short course in blowpipe analysis, followed by laboratory practice in the determination and study of minerals, with special reference to their economic value. For Chemical Juniors, elective for Agricultural and General Course Juniors.

Open only to students who have completed Chemistry 1 and 2.

Two exercises per week. 2nd S.

2. **Elementary Geology.** Mr. Barrows.

A brief course in the elements of geology. Special attention is given to local geology and excursions are made to various points of interest in the vicinity. For Agricultural Juniors, elective for General Course Juniors and Seniors.

Open only to students who have completed Zoology 5.

Three exercises per week. 2nd S.

3. **Historical Geology.** Mr. Barrows.

The development of the continents of the earth and the evolution and distribution of the animal and plant forms from the

*Courses 5 and 6 are to be given in 1908-1909 and then in alternate years with 7 and 8.

earliest times to the present. Recitations, lectures and laboratory work. Elective for Agricultural and General Course Seniors.

Three exercises per week. 1st S.

GERMAN.

PROF. WHORISKEY, MR. SPENCER.

1. **Elementary German.** Prof. Whoriskey.

German Grammar. Declension of articles, nouns, adjectives and pronouns; verbs, weak and strong. Reading of simple stories; conversation. Dictation. For Freshmen offering French for admission.

Three exercises per week. 1st S.

2. **Elementary German.** Prof. Whoriskey.

Continuation of Course 1. Verbs, modal auxiliaries, essentials of syntax. Composition, Reading and Translation; Poems. Dictation. For Freshmen offering French for admission.

Three exercises per week. 2nd S.

3. **German Prose of the Nineteenth Century.** Prof. Whoriskey. Mr. Spencer.

Reading and Translation. Composition based on some book read in class. For all Sophomores.

Three exercises per week. 1st S.

4. **Scientific German.** Prof. Whoriskey, Mr. Spencer.

Reading and Translation. Composition. For all Sophomores.

Three exercises per week. 2nd S.

*5. **Goethe.** Prof. Whoriskey.

His Life and Works. Elective for General Course Seniors.

Three exercises per week. 1st S.

*6. **Goethe.** Prof. Whoriskey.

Continuation of Course 5. Elective for General Course Seniors.

Three exercises per week. 2nd S.

*7. **Schiller.** Prof. Whoriskey.

Life and Works. Elective for General Course Seniors.

Three exercises per week. 1st S.

***8. Schiller.**

Continuation of Course 7. Elective for General Course Seniors.

Three exercises per week. 2nd S.

9. German Composition. Prof. Whoriskey.

One and one-half exercises per week. 1st S.

10. German Composition. Prof Whoriskey.

One and one-half exercises per week. 2nd S.

HISTORY.

PROF. SCOTT.

In the courses in History an important place is given to historical reading carried on in the reference room. In some cases a considerable part of the work is written.

Courses 1 and 2 and Courses 3 and 4 are given in alternate years. Courses 3 and 4 are offered in 1909—'10.

Courses 1 to 4 are open only to students who have passed in Ancient History.

Courses 5 to 7 are open only to students who have passed in History and Constitution of the United States.

1. History of Europe from 476 to 1492.

Recitations and collateral reading. For General Course Freshmen, elective for General Course Sophomores.

Three exercises per week. 1st S.

2. History of Europe from 1492 to 1715.

Recitations and collateral reading. For General Course Freshmen, elective for General Course Sophomores.

Three exercises per week. 2nd S.

3. History of Europe from 1715 to 1815. The French Revolution.

Recitations and collateral reading. For General Course Freshmen, elective for General Course Sophomores.

Three exercises per week. 1st S.

* Courses 7 and 8 are to be given in 1908-09 and then in alternate years with 6 and 7.

4. History of Europe since 1815.

Recitations and collateral reading. For General Course Freshmen, elective for General Course Sophomores.

Three exercises per week. 2nd S.

***5. French Prose of Nineteenth Century.** Prof. Whoriskey.

For Agricultural Seniors, elective for General Course Juniors.

Three exercises per week. 1st S.

6. Political and Constitutional History of the United States from 1783 to 1837.

For Agricultural Seniors, elective for General Course Juniors.

Three exercises per week. 2nd S.

7. Political and Constitutional History of the United States since 1837.

Elective for General Course Seniors.

Three exercises per week. 1st S.

HORTICULTURE.

PROF. PICKETT, MR. WICKS, MR. LUMSDEN.

With the rapid development of agricultural education, the science of horticulture has become more clearly defined. Horticulture is sub-divided into five classes, viz: (1) Pomology, or fruit growing; (2) Olericulture, or Vegetable Gardening; (3) Floriculture, or Flower Growing; (4) Landscape Gardening; and (5) Nursery Practice.

1. Principles of Horticulture. Prof. Pickett.

This course is elementary, and comprises the fundamentals of horticulture, emphasizing the sciences upon which horticulture rests and the scope and importance of its field. For Agricultural Freshmen. First eight weeks.

Three exercises per week. 1st S.

2. Olericulture.

Lectures and recitations upon the culture, classification and identification of vegetables. The storing and marketing of vegetables are also considered. For Agricultural Freshmen.

Open only to those who have completed Course 1.

Two exercises per week. 2nd S.

3. Practical Pomology. Mr. Wicks.

Dealing with problems of fruit growing such as location, choice of site, kind and adaptability of soil for fruit growing, soil management, planting of orchards, pruning, sprays and spraying, thinning, harvesting and marketing. Lectures and laboratory work. For Agricultural Sophomores.

Three exercises per week. 2nd S.

4. Greenhouse Construction and Management. Mr. Lumsden.

Lectures, recitations and laboratory work. This course aims to familiarize the student with modern methods of greenhouse work and the more important plants grown under glass. Soils, varieties, culture, marketing, enemies, etc., are studied. Each student is required to do practical work in propagating, potting, watering, ventilating, etc. A study is made of the history and development of different types of greenhouses, including methods of heating and general management. For Agricultural Juniors.

Two exercises per week. 1st S.

5. Landscape Gardening. Mr. Lumsden.

An elementary course in ornamental and landscape gardening with special reference to the beautifying of home surroundings. Elective for Agricultural Juniors.

Two exercises per week. 2nd S.

6. Vegetable Gardening under Glass. Mr. Lumsden.

A study of the methods of growing market vegetables in greenhouses. Lectures and practical exercises in the greenhouse. Elective for Agricultural Seniors.

Two exercises per week. 2nd S.

7. Nursery Management. Prof. Pickett.

A study of the methods of propagation and care of trees, shrubs and perennial plants in the nursery. Lectures, reference readings and practice. Elective for Agricultural Juniors.

Three exercises per week. 2nd S.

8. Small Fruit Culture. Mr. Wicks.

A comprehensive study of the small fruits such as the strawberry, raspberry, blackberry, currant and gooseberry. Each kind of fruit is studied with reference to all the essential points such

as history, classification, propagation, planting, pruning, enemies, diseases, picking and marketing. Elective for Agricultural Juniors.

Two exercises per week. 1st S.

9. **Commercial Floriculture.** Mr. Lumsden.

A study of the growing of cut flowers and decorative plants. Lectures and practical exercises in the greenhouse. Elective for Agricultural Seniors.

Three exercises per week. 1st S.

10. **Evolution and Improvement of Plants.** Prof. Pickett.

The application of the principles of evolution to the improvement of plants. Variation, selection and heredity as applied to the problems of plant breeding in agricultural practice. Elective for Agricultural Seniors.

Two exercises per week. 2nd S.

11. **Commercial Orcharding and Systematic Pomology.** Mr. Wicks.

This course deals with problems of marketing fruits, packing, transportation, storage, market requirements and formation of fruitgrowers' associations and handling of by-products. Lectures and reference reading. Elective for Agricultural Seniors.

Four exercises per week. 1st S.

12. **Advanced Landscape Gardening.** Mr. Lumsden.

A study of the principles and composition of landscape gardening as applied to public and private grounds. Lectures, reference readings, and plans. Elective for Agricultural Seniors. *Open only to students who have completed Course 7.*

Two exercises per week. 2nd S.

13. **Advanced Vegetable Gardening.**

The management of commercial vegetable gardening establishments; rotation of crops, manures, markets and special crops. Elective for Agricultural Seniors.

Two exercises per week. 2nd S.

MACHINE DESIGN.

PROF. PUTNAM, MR. LATON, MR. INGHAM.

1. **Mechanism.** Prof. Putnam.

The study of machine parts with respect to their forms, motions and modes of connection; the kinematics of fluids; the theory of the slide valve. For Electrical and Mechanical Sophomores.

Open only to students who have completed Mathematics 1—2.

Three exercises per week. 1st S.

2. **Mechanism.** Prof. Putnam.

Continuation of Course 1. For Electrical and Mechanical Sophomores. First ten weeks.

Three exercises per week. 2nd S.

3. **Theoretical Mechanics.** Prof. Putnam, Mr. Ingham.

Composition and resolution of forces, conditions of equilibrium, center of gravity, with special attention to plane surfaces, friction, the simple machines, laws of motion, motion in a resisting medium, constrained motion, impact, work and energy, moment of inertia, particularly of plane surfaces; also strength of materials. For Engineering Juniors.

Open only to students who have completed Mathematics 1—7 inclusive and Physics 1.

Four exercises per week. 1st S.

4. **Designing and Drawing.** Prof. Putnam.

The application of Course 3 to practical problems worked out in the drafting room. For Electrical and Mechanical Juniors.

Open only to students who have completed Mathematics 1—7 inclusive and Physics 1.

Four exercises per week. 1st S.

5. **Theoretical Mechanics.** Prof. Putnam, Mr. Ingham.

Continuation of Course 3. For Engineering Juniors.

Four exercises per week. 2nd S.

6. **Shop Machinery.** Prof. Putnam, Mr. Laton.

The design of shop machinery of all kinds, except power plant machinery. For Mechanical Juniors.

Three exercises per week. 2nd S.

MATHEMATICS.

PROF. PETTEE, MR. LATON.

1. **Algebra Completed.** Prof. Pettee, Mr. Laton.

For all Freshmen.

Four exercises per week. 1st S.

2. **Solid Geometry, with advanced course.** Mr. Laton.

For Engineering Freshmen entering without the subject, elective for Agricultural and General Course Freshmen.

Two exercises per week. 1st S.

3. **Plane and Spherical Trigonometry.** Prof. Pettee, Mr. Laton.

For all Freshmen. First ten weeks.

Four exercises per week. 2nd S.

4. **Surveying.** Prof. Pettee.

Recitations, field-work and plotting, including compass, transit, plane-table and level work. For Engineering and Agricultural Freshmen, elective for General Course Freshmen. Last seven weeks.

Four exercises per week. 2nd S.

5. **Analytical Geometry.** Prof. Pettee.

For Engineering Sophomores, elective for General Course Sophomores.

Five exercises per week. 1st S.

6. **Differential and Integral Calculus.** Prof. Pettee.

For Engineering Sophomores, elective for General Course Sophomores.

Five exercises per week. 2nd S.

7. **Differential Equations.** Prof. Pettee.

Elective for General Course Juniors.

Two exercises per week. 1st S.

8. **Quaternions.** Prof. Pettee.

Elective for General Course Juniors.

Two exercises per week. 2nd S.

9. Astronomy. Prof. Pettee.

Elective for General Course Juniors and Seniors.

Two exercises per week. 2nd S.

MECHANICAL ENGINEERING.

PROF. CARDULLO, PROF. HEWITT, PROF. PUTNAM.

1. Elements of Steam Engineering. Prof. Cardullo.

Descriptive course of boilers, furnaces, steam engines and turbines, steam power appliances and gas engines. For Electrical and Mechanical Sophomores. Last seven weeks.

Three exercises per week. 2nd S.

7. Thermodynamics. Prof. Cardullo.

Study of the thermodynamic properties of gases and vapors, and of the phenomena of operation of thermodynamic engines; analysis of the causes of energy losses and methods of minimization; interpretation of indicator and temperature-entropy diagrams; study of steam engines and turbines, boilers, gas engines and producers and refrigerating machinery. For Electrical and Mechanical Juniors and Chemical Seniors.

Open only to students who have completed Physics 1 and 2 and Mathematics 1 to 6.

Three exercises per week. 1st S.

8. Thermodynamics. Prof. Cardullo.

Continuation of Course 7. For Electrical and Mechanical Juniors.

Three exercises per week. 2nd S.

9. Mechanical Laboratory. Prof. Cardullo.

Study of apparatus and methods of calibration used in engineering investigations; testing of iron, steel and wood; valve setting and indicator practice. A written report will be required for which one hour additional credit will be given.

Open only to students who have completed Physics 1 and 2 and Mathematics 1 to 6.

Two exercises per week. 1st S.

10. Mechanical Laboratory. Prof. Cardullo.

Study of miscellaneous engineering materials and apparatus, and standard methods of testing; lubricants, cement, fuels,

boilers, engines, pumps, power-plant appliances and supplies, etc. For Electrical and Mechanical Juniors.

Open only to students who have completed Course 9.

Two exercises per week. 2nd S.

11. Hydraulics. Prof. Cardullo.

A study of the principles and practice of hydraulic machinery and measurements. For Electrical and Mechanical Seniors.

Open only to students who have completed Machine Design 5 and Physics 1 and 2.

Four exercises per week. 1st S.

12. Materials of Engineering. Prof. Cardullo.

A study of the properties, commercial forms, methods of preparation and use of engineering materials. For Electrical and Mechanical Seniors.

Three exercises per week. 1st S.

13. Mechanical Laboratory. Prof. Cardullo.

A critical study and detailed analysis of the performance of engineering apparatus, particularly of steam and gas engines, hydraulic apparatus, etc. For Electrical and Mechanical Seniors.

Open only to students who have completed Course 10.

Two exercises per week. 1st S.

14. Mechanical Laboratory. Prof. Cardullo.

Continuation of Course 13. For Mechanical Seniors.

Open only to students who have completed Course 13.

Two exercises per week. 2nd S.

15. Heat Engine Design. Prof. Cardullo.

Study of the structure and proportions of heat engines; design of valves and valve gears, governors, fly wheels and principal members of steam and gas engines and steam turbines. For Mechanical Seniors.

Five exercises per week. 1st S.

16. Shop Design and Equipment. Prof. Putnam.

A study of the proper choice and arrangement of tools, machinery and equipment of all kinds for shops and factories; the design of suitable buildings for housing the same and estimates

of quantities of material and cost of construction. Particular attention will be given to textile mills and machine shops. For Mechanical Seniors.

Four exercises per week. 2nd S.

17. Power Plant Design. Prof. Hewitt, Prof. Cardullo.

A study of different types of power plants, power plant apparatus and equipment and of controlling factors in the cost of power generation and distribution; the design of a power plant to meet given conditions. For Mechanical Seniors.

Two exercises per week. 2nd S.

18. Contracts and Specifications. Prof. Hewitt.

The laws and forms of engineering contracts; standard specifications for engineering materials and apparatus. For Electrical and Mechanical Seniors.

Two exercises per week. 2nd S.

19. Economics of Engineering. Prof. Cardullo.

A discussion of the principles and practice of systems of shop organization and management, cost keeping, wage payment and methods of cost reduction; also a discussion of engineering finance, welfare work, labor conditions, factory laws, etc. For Electrical and Mechanical Seniors.

Three exercises per week. 2nd S.

METEOROLOGY.

1. Meteorology.

Recitations and lectures on wind systems, precipitation, humidity, laws of storms and tornadoes and methods of prediction of atmospheric changes. For Agricultural Seniors, elective for General Course Seniors.

Two exercises per week. 1st S.

MILITARY SCIENCE AND TACTICS.

CAPT. HUNT.

All male students, unless members of the Senior Class, or physically unfit, are required to drill and attend recitations in Military Science.

Military Science 1 to 8 inclusive consists of Military Drill and includes all the practical instruction in the following subjects:

Close and Extended Order Drills by Company and Battalion, Advance and Rear Guards, Outposts, Marches, Ceremonies, Battalion Review, Parades and Guard Mounting, Calisthenics and Gymnastics, Rifle Practice, First Aid to the Injured.

1. Military Drill.
For Freshmen.
Two exercises per week. 1st S.

2. Military Drill.
Continuation of Course 1. For Freshmen.
Two exercises per week. 2nd S.

3. Military Drill.
For Sophomores.
Two exercises per week. 1st S.

4. Military Drill.
Continuation of Course 3. For Sophomores.
Two exercises per week. 2nd S.

5. Military Drill.
For Juniors.
Two exercises per week. 1st S.

6. Military Drill.
Continuation of Course 5. For Juniors.
Two exercises per week. 2nd S.

7. Military Drill.
Elective for Seniors only.
Two exercises per week. 1st S.

8. Military Drill.
Continuation of Course 5. Elective for Seniors only.
Two exercises per week. 2nd S.

9. Infantry Drill Regulations.
Practical instruction and lectures. For Freshmen.
One exercise per week. 1st S.

10. Manual of Guard Duty and Small Arms Firing Regulations.
For Freshmen.
One exercise per week. 2nd S.

11. Military Primer.

Recitations and map problems covering advance and rear guards; outposts; patrols, etc.

For Sophomores.

One exercise per week. 1st S.

12. Military Map Reading and Sketching.

For Sophomores.

One exercise per week. 2nd S.

13. Field Service Regulations.

Preparation of problems requiring the issuing of field orders, knowledge of marches, transportation, subsistence, etc. For Juniors.

One exercise per week. 1st S.

14. Army Regulations and Preparation of Requisitions, etc.

For Juniors.

One exercise per week. 2nd S.

15. Army Organization and Administration.

Lectures and preparation of military papers. Elective for Seniors only.

One exercise per week. 1st S.

16. Army Organization and Administration.

Continuation of Course 15. Elective for Seniors only.

One exercise per week. 2nd S.

PHILOSOPHY AND PEDAGOGY.

PROF. GROVES.

1. Psychology.

An introduction to the study of mental life. The practical needs of the student are related as closely as possible to the work of the course. Elective for General Course Sophomores and Seniors.

Three exercises per week. 1st S.

2. The History of Educational Theory.

The greater part of the course is taken up with the study of the modern educational reformers, Comemius, Rousseau, Pestalozzi,

Froebel, Spencer and Herbart. Elective for General Course Freshmen and Juniors.

Two exercises per week. 2nd S.

3. Philosophy of Education.

The meaning of education is defined from the aspect of the biological, the physiological, the social, the psychological and the philosophical. Horne's Philosophy of Education.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

4. The Problems of School Education.

The method of the recitation; management and discipline of classes, observation of teaching. Elective for General Course Juniors and Seniors.

Three exercises per week. 1st S.

5. School Administration.

Courses of study; school hygiene; school law; a discussion of the essential elements of good administration. Elective for General Course Juniors and Seniors.

Three exercises per week. 2nd S.

6. Introduction to Philosophy.

A general survey of the field of philosophy with special reference to the definition of its problems, its spirit, its method and its relation to the various sciences; the theory of thought and knowledge; the doctrine of nature and of mind. This course aims to acquaint students with the ultimate problems of thought and to suggest possible solutions. Elective for General Course Juniors and Seniors.

Three exercises per week. 1st S.

PHYSICS.

PROF. NESBIT.

1. Mechanics and Heat.

Mechanics: The principles and laws of general physics are illustrated by a number of experiments, and the student is taught to make ready application of his mathematics in the solution of problems.

It is intended to provide a foundation in the dynamics of solids, liquids and gases, and also in the subjects of statics and hydrostatics.

Instruction is given by lectures, recitations and problem work. The text used is Watson's Physics. Reference is made to Ames' Theory of Physics, Duff's Textbook of Physics, and other standard treatises.

Heat: The theories of heat are briefly discussed. The subdivisions of the subject, such as the nature of heat, its effects, thermometry, sources of heat, the transference and transformations of heat are considered in detail. Constant attention is given to the relation of these topics to the subject of thermo-dynamics. Watson's Physics is used as a text. For Agricultural and Engineering Sophomores, elective for General Course Sophomores.

Three exercises per week. 1st S.

2. Light, Sound and Electricity.

Light: The subject is approached from the geometrical and physical standpoint. A number of experiments are performed illustrative of wave motion in general, followed by a study of that form of wave motion upon which the modern theory is based.

The subject is developed progressively and due attention is given to such subjects as reflection, refraction, color, the spectrum, and interference and polarization phenomena.

The student makes a careful study of optical instruments of all classes. Watson's Physics is used as the text.

Sound: The course consists of lectures and recitations, considerable emphasis being laid upon the relation of the subject to the transmission of speech.

The text used is Stone's Elementary Lessons in Sound.

Electricity and Magnetism: Numerous experiments are performed to illustrate the various phenomena of electrostatics, magnetism, current electricity and electric waves. As the course advances, the attention of the student is constantly called to the applications of electricity to the arts and sciences. S. P. Thompson's Elementary Lessons in Electricity and Magnetism is used as a text. For Agricultural and Engineering Sophomores, elective for General Course Sophomores.

Three exercises per week. 2nd S.

3. Elements of Least Squares and the Precision of Measurements.

This course is intended to serve as an introduction to the work in the Physical Laboratory. It familiarizes the student with the

precautions necessary in taking experimental data and of properly using his data in order to secure the most reliable results.

A large number of problems are solved, illustrating the determination of physical constants and in deducing the constants of empirical equations. Bartlett's Least Squares is used as a text in Least Squares. The work in Precision of Measurements consists of a course of lectures and the solution of a number of problems illustrating the application of the subject. For Electrical and Mechanical Juniors, elective for General Course Juniors.

One exercise per week. 1st S.

4. Physical Laboratory.

The apparatus employed in the experimental part of Courses 7 and 8 is adapted to no special laboratory manual, and either notes are prepared for students' use or reference is made to the works of Watson, Ames and Bliss, E. L. Nichols, H. M. Godwin and others.

The laws of general physics are investigated experimentally. The student is encouraged to acquire skill in the manipulation of apparatus, habits of clearness and neatness in keeping records, as well as enthusiasm for independent and original investigation.

A careful study is made of the Analytical Balance, time measuring devices, heat measurements, the microscope, spectroscope, lens combinations, photometry, the laws of vibrating strings and the simple electrical measurements. The student has practice in the calibration of galvanometers and ammeters, the determination of the constants of instruments, the measurement of voltages, resistances, etc.

On the completion of Courses 4 and 5, an examination is given to test the student's knowledge of physical research, both in attacking a given problem and in thinking and acting for himself. For Electrical and Mechanical Juniors, elective for General Course Juniors.

One exercise per week. 1st S.

5. Physical Laboratory.

A continuation of Course 4. For Electrical and Mechanical Juniors, elective for General Course Juniors.

Three exercises per week. 2nd S.

A fee of ten dollars is required in Courses 4 and 5 to cover breakage, etc. Any unexpended balance is refunded to the student at the close of the college year.

6. Physical Laboratory.

Physical Laboratory work. Similar to Courses 4 and 5. For Chemical Juniors.

Three exercises per week. 2nd S.

POLITICAL SCIENCE.

PROF. SCOTT.

1. Political Economy.

An elementary course, with lectures upon some of the practical questions of the day. For General Course Sophomores, Agricultural Juniors and Engineering Seniors.

Three exercises per week. 2nd S.

2. Laws of Business.

Recitations supplemented by lectures and the discussion of cases. Elective for General Course Juniors and Seniors and Agricultural Seniors.

Three exercises per week. 1st S.

3. American Constitutional Law.

Use is made of Pomeroy's Constitutional Law, which is supplemented by the decisions of the United States Supreme Court. Special attention is given to the connections between American constitutions and American political history. Elective for General Course and Agricultural Seniors.

Three exercises per week. 1st S.

4 Money and Banking.

Recitations, readings and lectures. Elective for Agricultural Seniors and General Course Juniors and Seniors.

Courses 4 and 5 are given in alternate years. Course 4 will be offered in the year 1908—'09.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

5. Public Finance.

Recitations, readings and lectures. Elective for Agricultural Seniors and General Course Juniors and Seniors.

Courses 4 and 5 are given in alternate years. Course 5 will be offered in the year 1909—'10.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

SHOP WORK.

PROF. CARDULLO, MR. BROWN, MR. INGHAM.

Three hours' work in the shop is reckoned as one exercise.

1. Wood Work. Mr. Ingham.

Exercises in carpentry work, joinery and pattern making. For Engineering Freshmen, elective for General Course Freshmen.

Engineering Freshmen.

Two and one-half exercises per week. 1st S.

General Course Freshmen.

Two exercises per week. 1st S.

2. Forging. Mr. Brown.

This course consists of exercises in upsetting, drawing, forming and welding. For Engineering Freshmen, (Division 2). First ten weeks.

Two exercises per week. 2nd S.

3. Forging.

Same as Course 2. For Electrical and Mechanical Sophomores, (Division 1).

Two exercises per week. 1st S.

4. Machine Work. Mr. Brown.

A Course in Turning, Facing, Thread Cutting, Milling, Shaping, Scraping, Filing and Planing. For Mechanical and Electrical Sophomores.

Two and one-half exercises per week. 2nd S.

9. General Machine Work. Mr. Brown.

Continuation of Course 4. For Electrical and Mechanical Juniors.

One exercise per week. 1st S.

10. Manufacturing. Mr. Brown.

Construction and use of jigs and special fixtures; use of limit gauges, special tools, turret and screw machinery; manufacture of some simple machine, using special appliances. For Electrical and Mechanical Juniors.

One exercise per week. 2nd S.

11. Special Shop Work.

Work arranged to suit the needs of particular students.

12. Special Shop Work.

13. Wood Work. Mr. Ingham.

Same as Course 1. For Agricultural Freshmen. Last nine weeks.

One and one-half exercises per week. 1st S.

14. Forging. Mr. Brown.

For Agricultural Freshmen.

Two exercises per week. 2nd S.

15. Machine Work. Mr. Brown.

Same as Course 4. For Chemical Seniors.

Two exercises per week. 1st S.

SPANISH.

MR. SPENCER.

1. Elementary Spanish.

This course will consist of an elementary study of Spanish grammar, supplemented and followed by reading of easy Spanish texts.

Three exercises per week. 1st S.

2. Elementary Spanish.

This course will consist of a thorough review of Spanish grammar, based on the texts studied in Spanish 1, and reading of more advanced Spanish texts.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

ZOOLOGY.

PROF. SANDERSON, MR. BARROWS, MR. JACKSON.

The courses in Zoology are arranged in sequence for those studying Agriculture or Economic Entomology, and for those desiring a more general course fitting them for teaching or for medical studies, though any courses offered may be taken by those who have completed previous courses necessary.

1. Economic Entomology.

Insects affecting crops, domestic animals, etc., their life, histories and habits and the methods of combating them; special consideration of general farm methods for control of insects affecting staple crops, and of spraying, machinery and insecticides for combating truck and fruit insects. For Agricultural Sophomores, elective for General Course Sophomores.

Three exercises per week. 1st S.

2. General Entomology.

A general survey of the structure, habits and classification of the different orders of insects. Lectures, laboratory dissections and classification. For Agricultural Sophomores, elective for General Course Sophomores.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

3. Vertebrate Anatomy and Physiology.

The comparison of anatomy and physiology of vertebrate animals, the general physiology of higher animals, and laboratory dissections of a few typical forms. Elective for Agricultural and General Course Juniors.

Four exercises per week. 1st S.

4. Advanced Economic Entomology.

The methods of study and general principles of combating insect pests; the literature and history of economic entomology; practice in determining and rearing and combating insect pests. Elective for Agricultural Juniors or Seniors.

Open only to students who have completed Course 2.

Three exercises per week. 2nd S.

5. Advanced Entomology.

Advanced work in General Entomology; collecting, classification and anatomical studies. Elective for Agricultural Juniors and General Course Sophomores.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

6. Invertebrate Zoology.

The structure and life of the invertebrate animals, except insects. Lectures and laboratory dissections of typical forms. Elective for Agricultural Seniors and General Course Sophomores, Juniors and Seniors.

Three exercises per week. 1st S.

†7. General Physiology.

The vital phenomena of animal life with special reference to the nervous, digestive, muscular, secretory and sensory processes in the higher animal forms. Elective for Agricultural and General Course Juniors or Seniors.

Three exercises per week. 2nd S.

8. Evolution.

Lectures taking up the problems of variation, heredity, breeding, and selection from an experimental standpoint, and discussions of recent theories with their bearings on the question of evolution. This course is a basis for advanced work in plant and animal breeding. For Agricultural Seniors, elective for General Course Juniors and Seniors.

Three exercises per week. 1st S.

10 and 11. Advanced Zoology.

This course is arranged to suit the individual needs of students who elect Zoology for Senior year.

Open only to students who have completed previous courses and have shown proficiency in Zoology.

Three or four exercises per week throughout the year.

12. Biological Seminar.

Reports and discussions upon current literature of Zoology and Botany, special topics and observations. Elective for Agricultural and General Course Juniors and Seniors.

One exercise per week throughout the year.

FOUR YEAR COURSES.

COURSES OF STUDY AND SCHEDULE OF HOURS.

(For details see Description of Studies.)

Attendance at Chapel exercises is required of all students and attendance at Military Drill is required of all male students, unless members of the Senior Class or physically unfit.

AGRICULTURAL COURSE.

Freshman Year.

FIRST SEMESTER.

Chemistry 1	Inorganic Chemistry	3
Drawing 1	Industrial Drawing	2

†To be given only when elected by four or more students.

English 1	English Composition and Rhetoric	3
French 1 or *German 1*	Elementary French / Elementary German	3
Horticulture 1	Principles of Horticulture (first eight weeks)	1½
Mathematics 1	Algebra	4
**Mathematics 2*	Solid Geometry	2
Military Science 1	Drill	1
Military Science 9	Infantry Drill Regulations	1
Shop Work 13	Wood Shop (last nine weeks)	1½

SECOND SEMESTER.

Chemistry 2	Inorganic Chemistry	2
Drawing 4	Design of Farm Buildings	2
English 2	English Composition and Rhetoric	3
French 2 or German 2	Elementary French / Elementary German	3
Horticulture 2	Olericulture	2
Mathematics 3	Trigonometry (first ten weeks)	2½
Mathematics 4	Surveying (last seven weeks)	1½
Military Science 2	Drill	1
Military Science 10	Manual of Guard Duty, etc	1
Shop Work 14	Forge Shop	2

Sophomore Year.

FIRST SEMESTER.

An. Husb. 1	Breeds of Livestock	3
Botany 1	General Botany	3
Chemistry 4	Qualitative Analysis	3
German 3	German Prose of the Nineteenth Century	3
Military Science 3	Drill	1
Military Science 11	Military Primer	1
Physics 1	Mechanics and Heat	3
Zoology 1	Economic Entomology	3

SECOND SEMESTER.

Botany 2	General Botany	3
Chemistry 6	Organic Chemistry	3
German 4	Scientific German	3
Horticulture 3	Practical Pomology	3
Military Science 4	Drill	1
Military Science 12	Military Map Reading and Sketching	1
Physics 2	Light, Sound and Electricity	3
Zoology 2	General Entomology	3

*Elective.

Junior Year.

FIRST SEMESTER.

Agronomy 1	Farm Equipment and Farm Crops	3
†*Botany 3* or	Plant Pathology	4
†*Zoology 3*	Vertebrate Anatomy and Physiology	4
Dairying 1	Farm Dairying	4
Forestry 1	Principles of Forestry	3
Horticulture 4	Greenhouse Construction and Management	2
**Horticulture 8*	Small Fruit Culture	2
Military Science 5	Drill	1
Military Science 13	Field Service Regulations	1

SECOND SEMESTER.

Agronomy 2	Soils and Soil Physics	3
An. Husb. 3	Stock Feeding	3
**An. Husb. 4*	Veterinary Science	3
**An. Husb. 6*	Advanced Livestock	3
**Botany 4* or	Mycology	3
**Botany 5*	Plant Physiology	
**Dairying 3*	Technology of Milk	2
Geology 2	Elementary Geology	3
**Horticulture 5*	Landscape Gardening	3
**Horticulture 7*	Nursery Management	3
Military Science 6	Drill	1
Military Science 14	Army Regulations	1
Political Science 1	Political Economy	3
**Zoology 4* or	Advanced Economic Entomology	3
**Zoology 5* or	Advanced Entomology	
**Zoology 7*	General Physiology	

During the Junior Year students who desire and are qualified to take up work in the Biological or Chemical Divisions of the Agricultural Course may substitute work in these divisions for Dairying 1 and Animal Husbandry 3.

Senior Year.

FIRST SEMESTER.

Agronomy 5	Agricultural Seminar	2
History 5	American History to 1783	3
Meteorology 1	Meteorology	2
Thesis		2
Zoology 8	Evolution	3
Elective Courses		6

*Elective.
†Botany 3 should be elected by students intending to specialize in Horticulture, Zoology 3, by those intending to specialize in Animal Husbandry or Zoology.

SECOND SEMESTER.

Agronomy 6	Agr. History and Economics (first nine weeks)	2
Agronomy 7	Farm Mechanics (last eight weeks)	2
English 6	English Literature	3
History 6	Const. and Political History of U. S. (1783-1837)	3
Thesis		2
Elective Courses		6

ENGINEERING COURSES.

Freshman Year.

FIRST SEMESTER.

Chemistry 1	Inorganic Chemistry	3
Drawing 1	Industrial Drawing	2½
English 1	English Composition and Rhetoric	3
French 1 or *German 1*	Elementary French / Elementary German	3
Mathematics 1	Algebra	4
‡*Mathematics 2*	Solid Geometry	2
Military Science 1	Drill	1
Military Science 9.	Infantry Drill Regulations	1
Shop Work 1	Wood Work	2½

SECOND SEMESTER.

Chemistry 2	Inorganic Chemistry	2
†*Chemistry 4*	Qualitative Analysis (first division)	3
Drawing 2	Descriptive Geometry (first division)	3
Drawing 2	Descriptive Geometry (second division), (first ten weeks)	2
Drawing 3	Continuation of Drawing 2 (second division), (last seven weeks)	2
English 2	English Composition and Rhetoric	3
French 2 or *German 2*	Elementary French / Elementary German	3
Mathematics 3	Trigonometry (first ten weeks)	2½
Mathematics 4	Surveying (last seven weeks)	1½
Military Science 2	Drill	1
Military Science 10	Manual of Guard Duty, etc.	1
†*Shop Work 2*	Forging (second division) (first ten weeks)	2

---

*Elective.

‡For Freshmen entering without the subject.

†Division 1 elects Chemistry 4 instead of Shop Work 2 and Division 2 elects Shop Work 2 instead of Chemistry 4.

CHEMICAL ENGINEERING COURSE.

Sophomore Year.

FIRST SEMESTER.

Chemistry 5	Qualitative Analysis (first five weeks)	1½
Chemistry 10	Quantitative Analysis (last twelve weeks)	3½
Drawing 7	Elementary Machine Drawing and Free Hand Drawing of Chem. Apparatus	2
German 3	German Prose of the Nineteenth Century	3
Mathematics 5	Analytical Geometry	5
Military Science 3	Drill	1
Military Science 11	Military Primer	1
Physics 1	Mechanics and Heat	3

SECOND SEMESTER.

Chemistry 6	Organic Chemistry	3
Chemistry 11	Quantitative Analysis	6
German 4	Scientific German	3
Mathematics 6	Calculus	5
Military Science 4	Drill	1
Military Science 12	Military Map Reading and Sketching	1
Physics 2	Light, Sound and Electricity	3

Junior Year.

FIRST SEMESTER.

Chemistry 7	Chemistry of Plant and Animal Nutrition	2
Chemistry 8	Organic Chemical Laboratory	3
Chemistry 12	Advanced Quantitative Analysis	5
Chemistry 19	Chemical Journals	2
†*Chemistry 21*	Physical Chemistry	2
Machine Design 3	Theoretical Mechanics	4
Military Science 5	Drill	1
Military Science 13	Field Service Regulations	1

SECOND SEMESTER.

Chemistry 13	Advanced Quantitative Analysis	4
†*Chemistry 14* and	Industrial Chemistry	2
†*Chemistry 15* or	Metallurgy	1
†*Chemistry 22*	Physical and Electro-chemistry	3
Chemistry 20	Chemical Journals	2
Geology 1	Mineralogy	2
Machine Design 5	Theoretical Mechanics	4
Military Science 6	Drill	1
Military Science 14	Army Regulations	1
Physics 6	Physical Laboratory	3

†Given in alternate years.

Senior Year.

FIRST SEMESTER.

Chemistry 16	Assaying	1
Chemistry 21	Physical Chemistry	2
Chemistry 23	Chemical Research and Thesis	8
Elect. Engineering 21	Industrial Electricity	3
Mech. Engineering 7	Thermodynamics	3
**Military Science 7*	Drill	1
**Military Science 15*	Army Organization and Administration	1
Shop Work 15	Machine Shop	2

SECOND SEMESTER.

†*Chemistry 14* and	Industrial Chemistry	2
†*Chemistry 15* or	Metallurgy	1
†*Chemistry 22*	Physical and Electro-chemistry	3
Chemistry 24	Thesis	8
Elect. Engineering 22	Industrial Electricity	3
English 6	English Literature	3
**Military Science 8*	Drill	1
**Military Science 16*	Army Organization and Administration	1
Political Science 1	Political Economy	3

ELECTRICAL AND MECHANICAL ENGINEERING COURSES.

Sophomore Year.

FIRST SEMESTER.

‡*Chemistry 4*	Qualitative Chemical Analysis	3
Drawing 5	Descriptive Geometry (first division) (first seven weeks)	1
Drawing 6	Elementary Machine Drawing (first division), (last ten weeks)	1½
Drawing 6	Elementary Machine Drawing (second division)	2
German 3	German Prose of the Nineteenth Century	3
Mathematics 5	Analytical Geometry	5
Machine Design 1	Mechanism	3
Military Science 3	Drill	1
Military Science 11	Military Primer	1
Physics 1	Mechanics and Heat	3
‡*Shop Work 3*	Forging (first division)	2

*Elective.

† Given in alternate years.

‡ Division 1 elects Shop Work 3 instead of Chemistry 4, and Division 2 elects Chemistry 4 instead of Shop Work 3.

SECOND SEMESTER.

Drawing 8	Machine Drawing	2½
German 4	Scientific German	3
Mathematics 6	Calculus	5
Machine Design 2	Mechanism (first ten weeks)..	3
Mech. Engineering 1	Elements of Steam Engineering (last seven weeks).........	
Military Science 4	Drill	1
Military Science 12	Military Map Reading and Sketching	1
Physics 2	Light, Sound and Electricity....	3
Shop Work 4	Machine Work	2½

ELECTRICAL ENGINEERING COURSE.

Junior Year.

FIRST SEMESTER.

Elec. Engineering 1	Dynamo Electric Machinery.....	3
Machine Design 3	Theoretical Mechanics	4
Machine Design 4	Designing and Drawing	4
Mech. Engineering 7	Thermodynamics	3
Mech. Engineering 9	Mechanical Laboratory..........	2
Military Science 5	Drill	1
Military Science 13	Field Service Regulations	1
Physics 3	Least Squares	1
Physics 4	Physical Laboratory	1
Shop Work 9	Machine Work	1

SECOND SEMESTER.

Elect. Engineering 2	Dynamo Electric Machinery.....	3
Machine Design 5	Theoretical Mechanics	4
Machine Design 6	Shop Machinery	3
Mech. Engineering 8	Thermodynamics	3
Mech. Engineering 10	Mechanical Laboratory	2
Military Science 6	Drill	1
Military Science 14	Army Regulations	1
Physics 5	Physical Laboratory	3

Senior Year.

FIRST SEMESTER.

Elect. Engineering 17	Electrical Laboratory	2
Elect. Engineering 19	Dynamo Electric Machinery.....	3
Mech. Engineering 11	Hydraulics	4
Mech. Engineering 12	Materials of Engineering	3
Mech. Engineering 13	Mechanical Laboratory	3
Mech. Engineering 15	Heat Engine Design	5
**Military Science 7*	Drill	1
**Military Science 15*	Army Organization and Administration	1

*Elective.

SECOND SEMESTER.

Elect. Engineering 20	Dynamo Electric Machinery....	2
Mech. Engineering 14	Mechanical Laboratory	3
Mech. Engineering 16	Shop Design and Equipment....	4
Mech. Engineering 17	Power Plant Design	2
Mech. Engineering 19	Economics of Engineering.......	3
**Military Science 8*	Drill	1
**Military Science 16*	Army Organization and Administration	1
Political Science 1	Political Economy	3
Thesis	....	3

GENERAL COURSE.

The requirements for graduation from the General Course include (1) the completion of all required studies, (2) the completion of one hundred and forty-four semester hours and (3) the election of studies during the Sophomore, Junior and Senior Years according to the group system.

The group system requires that all General Course students shall elect one *major* and two *minor* courses; the *major* to consist of twenty-one credit hours including thesis, in one of the three groups, in addition to the required work of the Freshman Year; and the *minor* to consist of fifteen credit hours in each of the other two groups, in addition to the required work of the Freshman Year.

GROUP I.

Languages and Literature:—English; French; German; Spanish.

GROUP II.

Mathematics and Sciences:—Mathematics; Zoology; Drawing; Agriculture; Mechanical Engineering; Electrical Engineering; Chemistry; Botany; Physics; Geology; Meteorology.

GROUP III.

History; Social Science and Philosophy:—History; Political Science; Philosophy and Pedagogy.

Freshman Year.

FIRST SEMESTER.

Chemistry 1	Inorganic Chemistry	3
**Drawing 1*	Industrial Drawing	2

*Elective

English 1	English Composition and Rhetoric	3
French 1 or	Elementary French	3
German 1	Elementary German	
History 1	History of Europe from 476 to 1492	3
Mathematics 1	Algebra	4
**Mathematics 2*	Solid Geometry	2
Military Science 1	Drill	1
Military Science 9	Infantry Drill Regulations......	1
**Shop Work 1*	Wood Work	2

SECOND SEMESTER.

Chemistry 2	Inorganic Chemistry	2
†*Drawing 16*	Free Hand or Charcoal Drawing (Last seven weeks)	1½
English 2	English Composition and Rhetoric	3
French 2 or	Elementary French	3
German 2	Elementary German	
History 2	History of Europe from 1492 to 1715	3
Mathematics 3	Trigonometry (first ten weeks)..	2½
†*Mathematics 4*	Surveying (Last seven weeks)..	1½
Military Science 2	Drill	1
Military Science 10	Manual of Guard Duty..........	1
**Philosophy 2*	History of Educational Theory..	2

Sophomore Year.

FIRST SEMESTER.

†*Botany 1* or	General Botany	
†*Zoology 1* or	Economic Entomology	3
†*Zoology 6*	Invertebrate Zoology..........	
**Chemistry 4*	Qualitative Analysis	3
**Drawing 9*	Free Hand Drawing	2
**English 3*	Advanced English Composition and Criticism	3
German 3	German Prose of the Nineteenth Century	3
**History 1* or	History of Europe from 476 to 1492	3
**History 3*	History of Europe from 1715 to 1815	
**Mathematics 5*	Analytical Geometry	5
Military Science 3	Drill	1
Military Science 11	Military Primer	1
**Philosophy 1*	Psychology	3
**Physics 1*	Mechanics and Heat	3

*Elective.

† Freshmen are required to elect either Drawing 16 or Mathematics 4. Sophomores are required to elect one out of each group.

SECOND SEMESTER.

†*Botany 2* or	General Botany	3
†*Zoology 2* or	General Entomology	
†*Zoology 5*	Advanced Entomology	
**Drawing 10*	Free Hand Drawing	2
‡*English 6*	English Literature	3
German 4	Scientific German	3
**History 2* or	History of Europe from 1492 to 1715	3
**History 4*	History of Europe since 1815	
**Mathematics 6*	Calculus	5
Military Science 4	Drill	1
Military Science 12	Military Map Reading and Sketching	1
**Physics 2*	Light, Sound and Electricity	3
**Philosophy 2*	History of Educational Theory	2
Political Science 1	Political Economy	3

Junior Year.

FIRST SEMESTER.

All elective except Military Science and Drill and English 6.

Botany 3	Plant Pathology	4
Botany 6	Plant Histology	3
Chemistry 4	Qualitative Analysis	3
Drawing 11	Architectural Drawing	3
English 3	Advanced English Composition	3
English 5	English Novel	3
French 3	Scientific French	3
History 5	American History to 1783	3
Mathematics 7	Differential Equations	2
Military Science 5	Drill	1
Military Science 13	Field Service Regulations	1
Philosophy 4	Problems of School Education	3
Philosophy 6	Introduction to Philosophy	3
Physics 3	Least Squares and Precision of Measurements	1
Physics 4	Physical Laboratory	1
Political Science 2	Laws of Business	3
Spanish 1	Elementary Spanish	3
Zoology 3	Vertebrate Anatomy and Physiology	4
Zoology 6	Invertebrate Zoology	3
Zoology 8	Evolution	3

SECOND SEMESTER.

Botany 4	Mycology	3
Botany 5	Plant Physiology	3

*Elective.
†Students are required to elect one of the group.
‡Required in Sophomore or Junior year.

Chemistry 6	Organic Chemistry	3
Chemistry 8	Organic Chemical Laboratory...	3
Drawing 12	Architectural Drawing	3
English 4	English Drama	3
‡*English 6*	English Literature	3
French 4	French Prose, History and Travel	3
Geology 1	Mineralogy	2
Geology 2	Elementary Geology	3
History 6	Const. and Political History of U. S., 1783-1837...............	3
Mathematics 8	Quaternions	2
Military Science 6	Drill	1
Military Science 14	Army Regulations	1
Philosophy 3	Philosophy of Education	3
Philosophy 5	School Administration	3
Physics 5	Physical Laboratory............	3
Political Science 4 or *Political Science 5*	Money and Banking .... Public Finance	3
Spanish 2	Elementary Spanish	3
Zoology 7	General Physiology	3

Senior Year.

FIRST SEMESTER.

All elective.

Botany 3 or *Botany 6* or *Botany 7*	Plant Pathology .... Plant Histology .... Advanced Botany	3
Chemistry 7	Chemistry of Plant and Animal Nutrition	2
Drawing 13	Advanced Architectural Drawing	3
English 5	English Novel	3
French 5	French Prose of 19th Century....	3
Geology 3	Historical Geology	3
German 5	Goethe, His Life and Works....	3
History 7	Const. and Political History of U. S. since 1837	3
Meteorology 1	Meteorology	2
Military Science 7	Drill	1
Military Science 15	Army Organization and Administration	1
Philosophy 1	Psychology	3
Philosophy 4	Problems of School Education...	3
Philosophy 6	Introduction to Philosophy	3
Political Science 2	Laws of Business	3
Political Science 3	American Constitutional Law...	3
Spanish 1	Elementary Spanish	3
Thesis	....	2
Zoology 6	Invertebrate Zoology...........	3
Zoology 8	Evolution	3
Zoology 10	Advanced Zoology..............	3 or 4

†Required in either the Sophomore or Junior year.

SECOND SEMESTER.

Botany 4 or	Mycology	3
Botany 5 or	Plant Physiology	
Botany 8	Advanced Botany	
Drawing 14	Advanced Architectural Drawing	2
English 4	English Drama	3
English 7	American Literature	4
French 6	French Prose of 19th Century	3
Geology 2	Elementary Geology	3
German 6	Goethe (continued)	3
Mathematics 9	Astronomy	2
Military Science 8	Drill	1
Military Science 16	Army Organization and Administration	1
Philosophy 5	School Administration	3
Political Science 4 or	Money and Banking	3
Political Science 5	Public Finance	
Spanish 2	Elementary Spanish	3
Thesis		1 or 2
Zoology 7	General Physiology	3
Zoology 11	Advanced Zoology	3 or 4

AGRICULTURAL COURSE—FRESHMAN YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday		Mathematics 1	Chemistry 1	Military Sci. 1	Drawing 1
	Tuesday	English 1	French 1 German 1	Mathematics 1	Military Sci. 9	Drawing 1
	Wednesday		Chemistry 1 1st Div.	Chemistry 1 2nd Div.	Horticulture 1 (First eight weeks)	Shop Work 13 (Last nine weeks)
	Thursday	English 1	French 1 German 1	Mathematics 1	Mathematics 1	Horticulture 1 (First eight weeks) Shop Work 13 (Last nine weeks)
	Friday		Chemistry 1 1st Div.	Chemistry 1 2nd Div.	Military Sci. 1	Horticulture 1 (First eight weeks) Shop Work 13 (Last nine weeks)
	Saturday	English 1	French 1 German 1	Mathematics 1	Mathematics 1	
SECOND SEMESTER	Monday	Military Sci. 10		Chemistry 2	Military Sci. 2	Shop Work 14 (First ten weeks) Mathematics 4 (Last seven weeks)
	Tuesday	English 2	French 2 German 2		Mathematics 3 (First ten weeks)	Shop Work 14 (First ten weeks) Mathematics 4 (Last seven weeks)
	Wednesday	Drawing 4	Drawing 4	Horticulture 2	Mathematics 3 (First ten weeks)	Drawing 4 (First ten weeks) Mathematics 4 (Last seven weeks)
	Thursday	English 2	French 2 German 2	Mathematics 3 (First ten weeks)	Mathematics 3 (First ten weeks)	Horticulture 2
	Friday	Drawing 4	Drawing 4	Chemistry 2	Military Sci. 2	Drawing 4 (First ten weeks) Mathematics 4 (Last seven weeks)
	Saturday	English 2	French 2 German 2	Mathematics 3 (First ten weeks)	Mathematics 3 (First ten weeks)	

Mathematics 2, First Semester, hours to be arranged.

AGRICULTURAL COURSE—SOPHOMORE YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday		Military Sci. 11	†Botany 1	†Military Sci. 3	Chemistry 4
	Tuesday		Zoology 1	Physics 1	German 3	Chemistry 4
	Wednesday	Animal Husb. 1		Botany 1	Botany 1	Chemistry 4
	Thursday	Zoology 1	Zoology 1	Physics 1	German 3	Animal Husb. 1
	Friday	Animal Husb. 1		†	†Military Sci. 3	Zoology 1
	Saturday	Botany 1	Botany 1	Physics 1	German 3	
SECOND SEMESTER	Monday	Chemistry 6	Zoology 2	†Botany 2	†Military Sci. 4	Horticulture 3
	Tuesday		Chemistry 6	Physics 2	German 4	Botany 2
	Wednesday	Horticulture 3		Military Sci. 12		Botany 2
	Thursday		Chemistry 6	Physics 2	German 4	
	Friday	Horticulture 3		†Zoology 2	†Military Sci. 4	Zoology 2
	Saturday			Physics 2	German 4	

†These periods are transposed from December 1 to March 31.

AGRICULTURAL COURSE—JUNIOR YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	*Horticulture 8	Forestry 1		Military Sci. 5	Zoology 3 Botany 3
	Tuesday	Chemistry 7	Forestry 1		Agronomy 1	Horticulture 4
	Wednesday	Chemistry 7	Dairying 1	Zoology 3 Botany 3	Horticulture 4	Forestry 1
	Thursday	Dairying 1	Dairying 1	Dairying 1	Agronomy 1	Zoology 3 Botany 3
	Friday	*Horticulture 8	Dairying 1	Zoology 3 Botany 3	Military Sci. 5	Agronomy 1
	Saturday	Dairying 1	Dairying 1	Dairying 1	Military Sci. 13	
SECOND SEMESTER	Monday	*Horticulture 5	*Horticulture 5	Geology 2	Military Sci. 6	Agronomy 2
	Tuesday	*Horticulture 7 *Animal Husb. 6	Political Sci. 1	*Animal Husb. 4	Agronomy 2	*Botany 4 or 5 *Dairying 3 *Zoology 4 or 5
	Wednesday	*Botany 4 or 5	*Botany 4 or 5	Animal Husb. 3	Agronomy 2	*Animal Husb. 6 *Horticulture 7 *Zoology 4 or 5
	Thursday	*Horticulture 7 *Animal Husb. 6	Political Sci. 1	Animal Husb. 3	Geology 2	Geology 2
	Friday	*Horticulture 5	*Horticulture 5 *Dairying 3	*Animal Husb. 4	Military Sci. 6	Animal Husb. 3
	Saturday		Political Sci. 1	*Botany 4 or 5 *Animal Husb. 4 *Zoology 4 or 5	Military Sci. 14	

For hours of courses not scheduled, see instructor.

*Elective.

AGRICULTURAL COURSE—SENIOR YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	*Zoology 6	*Animal Husb. 7	*Dairying 6 *Horticulture 9	*Horticulture 11	*Agronomy 3
	Tuesday	Zoology 8	*Animal Husb. 7 Zoology 6	History 5	*Horticulture 11	Agronomy 5
	Wednesday		Meteorology 1	*Dairying 6 *Horticulture 9	*Agronomy 3	*Botany 5 *Animal Husb. 7
	Thursday	Zoology 8	*Botany 5	History 5	*Animal Husb. 7	*Agronomy 3 *Horticulture 11
	Friday		Meteorology 1	*Botany 5	*Horticulture 11	*Horticulture 9 *Zoology 6
	Saturday	Zoology 8		History 5		
SECOND SEMESTER	Monday	*Horticulture 10	Agronomy 6 (First nine weeks) Agronomy 7 (Last eight weeks)	History 6	*Agronomy 4	*Botany 5
	Tuesday	*Horticulture 6	Agronomy 6 (First nine weeks) Agronomy 7 (Last eight weeks)	English 6	*Animal Husb. 2	*Animal Husb. 5
	Wednesday	*Horticulture 10	Agronomy 6 (First nine weeks) Agronomy 7 (Last eight weeks)	History 6	*Animal Husb. 2	*Botany 5
	Thursday	*Horticulture 12 or *Horticulture 13	Agronomy 6 (First nine weeks) Agronomy 7 (Last eight weeks)	English 6	*Agronomy 4	*Horticulture 6
	Friday		*Animal Husb. 5	History 6		
	Saturday	*Horticulture 12 or *Horticulture 13	*Horticulture 12 or *Horticulture 13 *Botany 5	English 6		

*Elective.
For hours of courses not scheduled see instructor.

ENGINEERING COURSES—FRESHMAN YEAR.

FIRST DIVISION.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday		English 1	Chemistry 1	Military Sci. 1	Shop Work 1
	Tuesday	German 1	French 1	Military Sci. 9 (Sec. 1)	Mathematics 1	Shop Work 1
	Wednesday		English 1	Chemistry 1	Mathematics 1	Drawing 1 Shop Work 1
	Thursday	German 1	French 1	Mathematics 1	Mathematics 1	Drawing 1
	Friday		English 1	Chemistry 1	Military Sci. 1	Drawing 1
	Saturday	German 1	French 1	Mathematics 1	Mathematics 1	
SECOND SEMESTER	Monday	German 2	English 2	Chemistry 2	Military Sci. 2	Chemistry 4 (First ten weeks) Mathematics 4 (Last seven weeks)
	Tuesday	Drawing 2	French 2 Drawing 2	Mathematics 3 (First ten weeks)	Military Sci. 10 (1st sec.)	Chemistry 4 (First ten weeks) Mathematics 4 (Last seven weeks)
	Wednesday	German 2	English 2	Mathematics 3 (First ten weeks)	Military Sci. 10 (2d sec.)	Chemistry 4 (First ten weeks) Mathematics 4 (Last seven weeks)
	Thursday	Drawing 2	French 2 Drawing 2	Mathematics 3 (First ten weeks) Drawing 2 (Last seven weeks)	Mathematics 3 (First ten weeks) Drawing 2 (Last seven weeks)	Chemistry 4 (First ten weeks) Mathematics 4 (Last seven weeks)
	Friday	German 2	English 2	Chemistry 2	Military Sci. 2	Chemistry 4 (First ten weeks) Mathematics 4 (Last seven weeks)
	Saturday	Drawing 2	French 2 Drawing 2	Mathematics 3 (First ten weeks) Drawing 2 (Last seven weeks)	Mathematics 3 (First ten weeks) Drawing 2 (Last seven weeks)	

Mathematics 2, First Semester, hours to be arranged.

ENGINEERING COURSES—FRESHMAN YEAR.

SECOND DIVISION.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday		Mathematics 1	Chemistry 1	Military Sci. 1	Drawing 1
	Tuesday	English 1	French 1 German 1	Mathematics 1	Military Sci. 9 (Sec. 1)	Drawing 1
	Wednesday			Chemistry 1	Military Sci. 9 (Sec. 2)	Drawing 1 Shop Work 1
	Thursday	English 1	French 1 German 1	Mathematics 1	Mathematics 1	Shop Work 1
	Friday			Chemistry 1	Military Sci. 1	Shop Work 1
	Saturday	English 1	French 1 German 1	Mathematics 1	Mathematics 1	
SECOND SEMESTER	Monday		Military Sci. 10 (Sec. 1)	Chemistry 2	Military Sci. 2	Drawing 2 (First ten weeks) Mathematics 4 (Last seven weeks)
	Tuesday	English 2	French 2 German 2	Drawing 3 (Last seven weeks)	Mathematics 3 (First ten weeks) Drawing 3 (Last seven weeks)	Drawing 2 (First ten weeks) Mathematics 4 (Last seven weeks)
	Wednesday	Drawing 2 (First ten weeks)	Drawing 2 (First ten weeks)	Drawing 2 (First ten weeks)	Mathematics 3 (First ten weeks)	Shop Work 2 (First ten weeks) Mathematics 4 (Last seven weeks)
	Thursday	English 2	French 2 German 2	Mathematics 3 (First ten weeks) Drawing 3 (Last seven weeks)	Mathematics 3 (First ten weeks) Drawing 3 (Last seven weeks)	Shop Work 2 (First ten weeks) Mathematics 4 (Last seven weeks)
	Friday	Drawing 2 (First ten weeks)	Drawing 2 (First ten weeks)	Chemistry 2	Military Sci. 2	Shop Work 2 (First ten weeks) Mathematics 4 (Last seven weeks)
	Saturday	English 2	German 2 French 2	Mathematics 3 (First ten weeks) Drawing 3 (Last seven weeks)	Mathematics 3 (First ten weeks) Drawing 3 (Last seven weeks)	

Mathematics 2, First Semester, hours to be arranged.

CHEMICAL ENGINEERING COURSE—SOPHOMORE YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	Chemistry 5 (First five weeks.) Chemistry 10 (Last twelve Weeks)	Chemistry 5 (First five weeks.) Chemistry 10 (Last twelve weeks)	†Chemistry 5 (First five weeks) †Chemistry 10 (Last twelve weeks)	†Military Sci. 3	Chemistry 5 (First five weeks) Chemistry 10 (Last twelve weeks)
	Tuesday	Mathematics 5		Physics 1	German 3	Chemistry 5 (First five weeks) Chemistry 10 (Last twelve weeks)
	Wednesday	Mathematics 5	Chemistry 5 (First five weeks.) Chemistry 10 (Last twelve weeks.)	Chemistry 5 (First five weeks) Chemistry 10 (Last twelve weeks)	Chemistry 5 (First five weeks) Chemistry 10 (Last twelve weeks)	Chemistry 5 (First five weeks) Chemistry 10 (Last twelve weeks)
	Thursday	Mathematics 5	Mathematics 5	Physics 1	German 3	Drawing 7
	Friday	Mathematics 5	Military Sci. 11	†	†Military Sci. 3	Drawing 7
	Saturday	Mathematics 5	Mathematics 5	Physics 1	German 3	
SECOND SEMESTER	Monday	Chemistry 6	Military Sci. 12	†	†Military Sci. 4	Chemistry 11
	Tuesday	Mathematics 6	Chemistry 6	Physics 2	German 4	Chemistry 11
	Wednesday	Mathematics 6	Chemistry 11	Chemistry 11	Chemistry 11	Chemistry 11
	Thursday	Mathematics 6	Chemistry 6	Physics 2	German 4	Chemistry 11
	Friday	Mathematics 6	Mathematics 6	†	†Military Sci. 4	Chemistry 11
	Saturday	Mathematics 6	Mathematics 6	Physics 2	German 4	

†These periods are transposed from December 1 to March 31.

CHEMICAL ENGINEERING COURSE—JUNIOR YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	Chemistry 8	Chemistry 19	Machine Design 3	Military Sci. 5	Chemistry 12
	Tuesday	Chemistry 7	Chemistry 12	Chemistry 21	Chemistry 12	Chemistry 12
	Wednesday	Chemistry 7	Chemistry 19	Machine Design 3		Chemistry 12
	Thursday	Machine Design 3		Chemistry 21	Chemistry 12	Chemistry 8
	Friday	Chemistry 12	Chemistry 12	Chemistry 12	Military Sci. 5	Chemistry 8
	Saturday		Machine Design 3		Military Sci. 13	
SECOND SEMESTER	Monday	Geology 1	Geology 1	Machine Design 5	Military Sci. 6	Chemistry 13
	Tuesday	Machine Design 5		Chemistry 20	Chemistry 14 Chemistry 15 Chemistry 22	Chemistry 13
	Wednesday	Machine Design 5	Chemistry 13	Chemistry 13	Chemistry 13	Physics 6
	Thursday	Chemistry 13	Chemistry 13	Chemistry 20	Chemistry 14 Chemistry 15 Chemistry 22	Physics 6
	Friday	Geology 1	Geology 1		Military Sci. 6	Physics 6
	Saturday	Chemistry 13	Chemistry 13	Machine Design 5	Chemistry 14 Chemistry 15 Chemistry 22 Military Sci. 14	

CHEMICAL ENGINEERING COURSE—SENIOR YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	Elect. Eng. 21	Chemistry 23	Chemistry 23	Chemistry 23	Chemistry 23
	Tuesday	Elect. Eng. 21	Elect. Eng. 21	Chemistry 21		Chemistry 23
	Wednesday	Shop Work 15	Shop Work 15	Shop Work 15	Mech. Eng. 7	Chemistry 23
	Thursday	Chemistry 23	Chemistry 23	Chemistry 21	Chemistry 23	Chemistry 23
	Friday	Elect. Eng. 21	Mech. Eng. 7	Chemistry 23	Chemistry 23	Chemistry 23
	Saturday	Mech. Eng. 7	Chemistry 16	Chemistry 16	Chemistry 16	
SECOND SEMESTER	Monday	Chemistry 24	Chemistry 24	Chemistry 24	Chemistry 24	Chemistry 24
	Tuesday	Political Sci. 1	Elect. Eng. 22	English 6	Chemistry 14 Chemistry 15 Chemistry 22	Chemistry 24
	Wednesday	Elect. Eng. 22	Elect. Eng. 22	Chemistry 24	Chemistry 24	Chemistry 24
	Thursday	Political Sci. 1		English 6	Chemistry 14 Chemistry 15 Chemistry 22	Chemistry 24
	Friday	Elect. Eng. 22	Chemistry 24	Chemistry 24	Chemistry 24	Chemistry 24
	Saturday	Political Sci. 1		English 6	Chemistry 14 Chemistry 15 Chemistry 22	

ELECTRICAL AND MECHANICAL ENGINEERING COURSES—SOPHOMORE YEAR.

Semester	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	Machine Design 1	Military Sci. 11	†	†Military Sci. 3	Chemistry 4 Shop Work 3
	Tuesday	Mathematics 5		Physics 1	German 3	Chemistry 4 Shop Work 3
	Wednesday	Mathematics 5	Machine Design 1			Drawing 5 (Div. 1) (1st 7 wks.) Chemistry 4
	Thursday	Mathematics 5	Mathematics 5	Physics 1	German 3	Drawing 5 (Div. 1) (1st 7 wks.) Drawing 6 (Div. 2)
	Friday	Mathematics 5		†Machine Design 1	†Military Sci. 3	Drawing 5 (Div. 1) (1st 7 wks.) Drawing 6 (Div. 2)
	Saturday	Mathematics 5	Mathematics 5	Physics 1	German 3	
SECOND SEMESTER	Monday	Machine Design 2 (First ten weeks) Mech. Eng. 1 (Last seven weeks)		†	†Military Sci. 4	Shop Work 4
	Tuesday	Mathematics 6		Physics 2	German 4	Shop Work 4
	Wednesday	Mathematics 6	Machine Design 2 (First ten weeks) Mech. Eng. 1 (Last seven weeks)	Military Sci. 12		Drawing 8 Shop Work 4
	Thursday	Mathematics 6		Physics 2	German 4	Drawing 8
	Friday	Mathematics 6	Mathematics 6	†Machine Design 2 (First ten weeks) †Mech. Eng. 1 (Last seven weeks)	†Military Sci. 4	Drawing 8
	Saturday	Mathematics 6	Mathematics 6	Physics 2	German 4	

†These periods are transposed from December 1 to March 31.

ELECTRICAL ENGINEERING COURSE—JUNIOR YEAR.

Semester	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday		Elect. Eng. 1	Machine Design 3	Military Sci. 5	Physics 3 Physics 4
	Tuesday	Machine Design 4	Machine Design 4	Machine Design 4	Machine Design 4	Physics 3 Physics 4
	Wednesday	Machine Design 4	Elect. Eng. 1	Machine Design 3	Mech. Eng. 7	Shop Work 9
	Thursday	Machine Design 3	Machine Design 4	Machine Design 4	Machine Design 4	Machine Design 4
	Friday	Machine Design 4	Mech. Eng. 7	Elect. Eng. 1	Military Sci. 5	Mech. Eng. 9
	Saturday	Mech. Eng. 7	Machine Design 3	Mech. Eng. 9	Military Sci. 13	
SECOND SEMESTER	Monday		Elect. Eng. 2	Machine Design 5	Military Sci. 6	Elect. Eng 4
	Tuesday	Machine Design 5	Shop Work 10	Shop Work 10	Shop Work 10	Mech. Eng. 10
	Wednesday	Machine Design 5	Elect. Eng. 2	Mech. Eng. 8		Physics 5
	Thursday	Elect. Eng. 4		Elect. Eng. 6	Mech. Eng. 8	Physics 5
	Friday	Mech. Eng. 10	Mech. Eng. 8	Elect. Eng 2	Military Sci. 6	Physics 5
	Saturday			Machine Design 5	Military Sci. 14	

ELECTRICAL ENGINEERING COURSE—SENIOR YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	Elect. Eng. 15		Mech. Eng. 11	Military Sci. 7	Mech. Eng. 13
	Tuesday	Mech. Eng. 12		Elect. Eng. 13		Elect. Eng. 15
	Wednesday		Mech. Eng. 11	Elect. Eng. 11	Mech. Eng. 13	
	Thursday	Mech. Eng. 12	Elect. Eng. 11	Mech. Eng. 11	Elect. Eng. 13	
	Friday			Mech. Eng. 11	Military Sci. 7	Elect. Eng. 15
	Saturday	Mech. Eng. 12	Elect. Eng. 11		Military Sci. 15	
SECOND SEMESTER	Monday	Mech. Eng. 19	Elect. Eng. 12		Military Sci. 8	
	Tuesday	Political Sci. 1		Mech. Eng. 14		Elect. Eng. 16
	Wednesday			Elect. Eng. 12	Mech. Eng. 19	Mech. Eng. 14
	Thursday	Political Sci. 1	Elect. Eng. 12			Elect. Eng. 16
	Friday		Elect. Eng. 12	Mech. Eng. 19	Military Sci. 8	
	Saturday	Political Sci. 1			Military Sci. 16	

MECHANICAL ENGINEERING COURSE—JUNIOR YEAR.

Semester	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday		Elect. Eng. 1	Machine Design 3	Military Sci. 5	Physics 3 Physics 4
	Tuesday	Machine Design 4	Machine Design 4	Machine Design 4	Machine Design 4	Physics 3 Physics 4
	Wednesday	Machine Design 4	Elect. Eng. 1	Machine Design 3	Mech. Eng. 7	Shop Work 9
	Thursday	Machine Design 3	Machine Design 4	Machine Design 4	Machine Design 4	Machine Design 4
	Friday	Machine Design 4	Mech. Eng. 7	Elect. Eng. 1	Military Sci. 5	Mech. Eng. 9
	Saturday	Mech. Eng. 7	Machine Design 3	Mech. Eng. 9	Military Sci. 13	
SECOND SEMESTER	Monday		Elect. Eng. 2	Machine Design 5	Military Sci. 6	Machine Design 6
	Tuesday	Machine Design 5	Shop Work 10	Shop Work 10	Shop Work 10	Mech. Eng. 10
	Wednesday	Machine Design 5	Elect. Eng. 2	Mech. Eng. 8	Machine Design 6	Physics 5
	Thursday	Machine Design 6	Machine Design 6	Machine Design 6	Mech. Eng. 8	Physics 5
	Friday	Mech. Eng. 10	Mech. Eng. 8	Elect. Eng. 2	Military Sci. 6	Physics 5
	Saturday	Machine Design 6	Machine Design 6	Machine Design 5	Military Sci. 14	

MECHANICAL ENGINEERING COURSE—SENIOR YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	Mech. Eng. 15	Elect. Eng. 19	Mech. Eng. 11	Military Sci. 7	Mech. Eng. 13
	Tuesday	Mech. Eng. 12	Mech. Eng. 15	Mech. Eng. 15	Mech. Eng. 15	
	Wednesday	Mech. Eng. 15	Mech. Eng. 11	Elect Eng. 19	Mech. Eng. 13	Mech. Eng. 15
	Thursday	Mech. Eng. 12		Mech. Eng. 11		Elect. Eng. 17
	Friday		Elect. Eng. 19	Mech. Eng. 11	Military Sci. 7	
	Saturday	Mech. Eng. 12	Mech. Eng. 15	Mech. Eng. 15	Mech. Eng. 15	
SECOND SEMESTER	Monday	Mech. Eng. 19		Elect. Eng. 20	Military Sci. 8	Thesis
	Tuesday	Political Sci. 1	Mech. Eng. 17	Mech. Eng. 14		Thesis
	Wednesday	Elect. Eng. 20	Mech. Eng. 16		Mech. Eng. 19	Mech. Eng. 14
	Thursday	Political Sci. 1	Thesis	Thesis	Thesis	Mech. Eng. 16
	Friday		Mech. Eng. 16	Mech. Eng. 19	Military Sci. 8	Mech. Eng. 16
	Saturday	Political Sci. 1	Mech. Eng. 17			

GENERAL COURSE—FRESHMAN YEAR.

Semester	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday		Mathematics 1	Chemistry 1	Military Sci. 1	*Drawing 1
	Tuesday	English 1	French 1 German 1	Mathematics 1	Military Sci. 9	*Drawing 1
	Wednesday		History 1 or History 3	Chemistry 1		*Shop Work 1
	Thursday	English 1	French 1 German 1	Mathematics 1	Mathematics 1	History 1 or History 3
	Friday		History 1 or History 3	Chemistry 1	Military Sci. 1	*Shop Work 1
	Saturday	English 1	French 1 German 1	Mathematics 1	Mathematics 1	
SECOND SEMESTER	Monday	Military Sci. 10	*Philosophy 2	Chemistry 2	Military Sci. 2	Drawing 16 (Last seven weeks) Mathematics 4 (Last seven weeks)
	Tuesday	English 2	French 2 German 2		Mathematics 3 (First ten weeks)	Drawing 16 (Last seven weeks) Mathematics 4 (Last seven weeks)
	Wednesday		History 2 or History 4	*Philosophy 2	Mathematics 3 (First ten weeks)	Drawing 16 (Last seven weeks) Mathematics 4 (Last seven weeks)
	Thursday	English 2	French 2 German 2	Mathematics 3 (First ten weeks)	Mathematics 3 (First ten weeks)	History 2 or History 4
	Friday		History 2 or History 4	Chemistry 2	Military Sci. 2	Drawing 16 (Last seven weeks) Mathematics 4 (Last seven weeks)
	Saturday	English 2	French 2 German 2	Mathematics 3 (First ten weeks)	Mathematics 3 (First ten weeks)	

*Elective.
Mathematics 2, First Semester, hours to be arranged.

GENERAL COURSE—SOPHOMORE YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	‡Zoology 6	Military Sci. 11	‡†Botany 1	†Military Sci. 3	*Chemistry 4
	Tuesday	*Mathematics 5	‡Zoology 1 ‡Zoology 6	*Philosophy 1 *Physics 1	German 3	*Chemistry 4
	Wednesday	*Mathematics 5	*History 1 *History 3	‡Botany 1	‡Botany 1	*Chemistry 4
	Thursday	‡Zoology 1 *Mathematics 5	‡Zoology 1	*Philosophy 1 *Physics 1	German 3	*History 1 *History 3
	Friday	*Mathematics 5	*History 1 or *History 3	‡	†Military Sci. 3	‡Zoology 1 ‡Zoology 6
	Saturday	*Mathematics 5 ‡Botany 1	*Mathematics 5 ‡Botany 1	*Philosophy 1 *Physics 1	German 3	
SECOND SEMESTER	Monday		‡Zoology 2	‡†Botany 2	†Military Sci. 4	
	Tuesday	*Mathematics 6	Political Sci. 1	English 6 *Physics 2	German 4	‡Botany 2 ‡Zoology 5
	Wednesday	*Mathematics 6	*History 2 *History 4	Military Sci. 12		‡Botany 2 ‡Zoology 5
	Thursday	*Mathematics 6	Political Sci. 1	English 6 *Physics 2	German 4	*History 2 *History 4
	Friday	*Mathematics 6	*History 2 *History 4	‡†Zoology 2	†Military Sci. 4	‡Zoology 2
	Saturday	*Mathematics 6	Political Sci. 1	English 6 *Physics 2 ‡Zoology 5	German 4	

†These periods are transposed from December 1 to March 31.

‡Students are required to select for 1st Semester, Zoology 1 or 6, or Botany 1, and for 2nd Semester, Zoology 2 or 5, or Botany 2

*Elective.

GENERAL COURSE—JUNIOR YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	Zoology 6	French 3	English 3	Philosophy 4 Military Sci. 5	Botany 3 Chemistry 4 Spanish 1 Zoology 3
	Tuesday	Zoology 8	Political Sci. 2 Zoology 6	History 5		Chemistry 4 Spanish 1
	Wednesday		French 3	Botany 3 Zoology 3	Philosophy 4 English 3	Chemistry 4 Spanish 1
	Thursday	Zoology 8	Political Sci. 2	History 5		Botany 3 Zoology 3 Zoology 6
	Friday		French 3	Botany 3 Zoology 3	Philosophy 4 Military Sci. 5	English 3
	Saturday	Zoology 8	Political Sci. 2	History 5	Military Sci. 13	
SECOND SEMESTER	Monday	Chemistry 6 Geology 1	French 4 Mathematics 9	Geology 2 History 6	Philosophy 5 Military Sci. 6	Spanish 2
	Tuesday		Chemistry 6 Philosophy 3	English 6	Political Sci. 4 Political Sci. 5	English 4 Spanish 2
	Wednesday		French 4 Mathematics 9	History 6	Philosophy 5 Geology 2	Spanish 2
	Thursday		Chemistry 6 Philosophy 3	English 6	Political Sci. 4 Political Sci. 5	English 4 Geology 2
	Friday	Geology 1	French 4	History 6	Philosophy 5 Military Sci. 6	English 4
	Saturday		Philosophy 3	English 6	Political Sci. 4 Political Sci. 5 Military Sci. 14	

For hours of courses not scheduled, see instructor.
All elective.

GENERAL COURSE—SENIOR YEAR.

	Day	8-9	9-10	10-11	11-12	P. M.
FIRST SEMESTER	Monday	German 5	Zoology 6 Philosophy 6	French 5	Philosophy 4 Political Sci. 3	Botany 6 History 7 Spanish 1
	Tuesday	English 5 Zoology 8	Political Sci. 2 Zoology 6	French 9 Philosophy 1		Spanish 1
	Wednesday	German 5	Philosophy 6 Meteorology 1	Botany 6 French 5	Philosophy 4 Political Sci. 3	History 7 Spanish 1
	Thursday	English 5	Zoology 8 Political Sci. 2	French 9 German 9 Philosophy 1		Zoology 6
	Friday	German 5	Philosophy 6 Meteorology 1	French 5	Philosophy 4 Political Sci. 3	Botany 6 History 7
	Saturday	English 5 Zoology 8	Political Sci. 2	German 9 Philosophy 1		
SECOND SEMESTER	Monday	German 6	Mathematics 9	French 6 Geology 2	Philosophy 5 English 7	Spanish 2
	Tuesday		Philosophy 3	French 10	Political Sci. 4 or Political Sci. 5	English 4 Spanish 2
	Wednesday	German 6	Mathematics 9	French 6	Philosophy 5 English 7	Spanish 2
	Thursday		Philosophy 3	German 10 French 10	Geology 2 Political Sci. 4 or Political Sci. 5	English 4 Geology 2
	Friday	German 6		French 6	Philosophy 5 English 7	English 4 English 7
	Saturday		Philosophy 3	German 10	Political Sci. 4 or Political Sci. 5	

For hours of courses not scheduled, see instructor.
All elective

TWO YEAR COURSE IN AGRICULTURE.

This course was established by the state legislature in 1895, and provides an opportunity for those students to secure a training for their life work who do not have the time, money or preparation to take a four year college course.

The course is especially arranged and suited for the young, bright boys of the farm, who expect to make a business of some line of agricultural or horticultural work. Although it is open to students who have had no previous training on the farm, the entrance of such is not encouraged because of their lack of practical experience. By independent work and close application, however, inexperienced students sometimes pass the course with credit.

Three new and important changes in the course have been made this year. The first is the shortening of the school year from thirty-five to thirty weeks. This change is made for the purpose of having the students complete their year's work about the last of April so as to be able to go home for the spring work on the farm or to accept salaried positions for the summer. It also permits of more than four months' time for those students who are dependent upon their own resources to earn money for the following year. The second change is the separation of the two and four year classes all the way through the course. This separation has not heretofore been made in most of the agricultural and horticultural subjects, but with an increased teaching force in these two departments for the coming year, it is made complete. The making of the classes separate and distinct makes it possible to plan and give the work of the two year course in a manner best suited to the needs of its students. In short, the course has been made just as practical as possible. The third change is the division of the year into two terms instead of three. The first term will be eighteen weeks in length and the second twelve.

The work of the first year is largely preparatory, being a study of the sciences underlying agriculture, together with some elementary agricultural and horticultural work. The second year contains optional studies so that it is possible for students to specialize in animal industry, dairying, forestry or greenhouse work. Ten hours per week on the average are spent in practical work on the farm, in the barn, greenhouses or shops.

ADMISSION.

The course is open to those who can pass a fair and reasonable examination in reading, spelling, writing, arithmetic, English grammar, geography and history of the United States. Applicants, unless over eighteen years of age, who do not bring high school or other satisfactory certificates to show their proficiency in these subjects, will be given an entrance examination on Tuesday afternoon and Wednesday morning of the opening week of school. Applicants who are over eighteen years of age will be admitted without examination.

OPENING.

The course for the year will open Wednesday, September 17, 1908, and close Wednesday, May 5, 1909. A Christmas vacation of two weeks and a spring vacation of five days will be given.

EXPENSES.

The expenses of the course will vary with the tastes and frugality of the students and the kind of accommodations which they secure. The total average expense for the year is not far from $250. Many students by working for their board or room rent, or by doing various kinds of work about the college or village, are able to go through the year with a cash outlay not exceeding $150.

CERTIFICATES.

No degree is given at the end of the course, but a certificate of graduation is issued upon the completion of it or its equivalent.

DESCRIPTION OF STUDIES.

AGRONOMY.

31. Elementary Agriculture.

Text-book and recitations upon the elementary principles of Agriculture, including a study of the soil, the plant and the animal, and their relations to each other; also a brief study of the different breeds of livestock, their breeding and feeding. For Two Year Agricultural Students, First Year.

Three exercises per week. 1st S.

32. Farm Equipment and Farm Crops.

This course is similar to Agronomy 1, although less detailed. For Two Year Agricultural Students, Second Year.

Three exercises per week. 1st S.

33. Soils and Soil Physics.

This course is similar to Agronomy 2, but involves less mathematics and physics. For Two Year Agricultural Students, Second Year.

Three exercises per week. 2nd S.

34. Manures and Fertilizers.

Text-book and recitations upon the constituents of farm manures, and chemical fertilizers, the care and application of manures, the mixture of fertilizers and the modifications required by different soils and crops. For Two Year Agricultural Students, Second Year.

Two exercises per week. 2nd S.

ANIMAL HUSBANDRY.

31. Breeds of Live Stock.

Similar to An. Husb. 1. For Two Year Agricultural Students, Second Year.

Three exercises per week. 1st S.

32. Sheep Raising.

Lectures and recitations upon the breeds of sheep; their adaptability to this section; their care and management; their fitting for the shows and feeding for market purposes; the growing of hot house lambs. Also practical exercises in judging the various breeds. Elective for Two Year Agricultural Students, Second Year.

Three exercises per week. 1st S.

33. Feeds and Feeding.

Similar to An. Husb. 3. For Two Year Agricultural Students, Second Year.

Three exercises per week. 2nd S.

34. Animal Breeding.

Similar to An. Husb. 2. Elective for Two Year Agricultural Students, Second Year.

Three exercises per week. 2nd S.

35. Veterinary.

Similar to An. Husb. 4. Elective for Two Year Agricultural Students, Second Year.

Three exercises per week. 2nd S.

36. Poultry.

Similar to An. Hus. 5. Elective for Two Year Agricultural Students, Second Year.

Two exercises per week. 2nd S.

BOTANY.

PROF. BROOKS, MR. LEWIS.

31. Elements of Botany.

A general view of the life processes and structure of plants, followed by the study in detail of a few type forms. Recitations and laboratory work. For Two Year Agricultural Students, First Year.

Three exercises per week. 1st S.

32. Plant Diseases.

A study of the more important fungous diseases and their prevention. Lectures, recitations and laboratory work.

Open only to students who have completed Course 1.

Three exercises per week. 2nd S.

CHEMISTRY.

PROF. MORSE.

31. Elementary Applications.

An elementary course, with special reference to the elements of plant food, composition of fertilizers, elements subject to exhaustion in soils, etc. For Two Year Agricultural Students, First Year.

Two exercises per week. 2nd S.

DAIRYING.

ASSOC. PROF. RASMUSSEN.

31. Milk and Milk Testing.

Lectures and recitations on the secretion, composition and properties of milk, the Babcock test and lactometer. Comparative

study of different systems of creaming and different factors influencing the efficiency of the hand separator. For Two Year Agricultural Students, First Year.

Three exercises per week. 2nd S.

32. Butter Making.

This includes pasteurization, commercial starters, cream ripening, churning, marketing and scoring butter. Elective for Two Year Agricultural Students, Second Year.

Three exercises per week. 1st S.

33. Technology of Milk.

Same as Course 3. Elective for Two Year Agricultural Students, Second Year.

Two exercises per week. 2nd S.

DRAWING.

31. Two Year Agricultural Students, Second Year.

One exercise per week. 1st S.

ENGLISH.

31. Grammar and Elementary Composition.

For Two Year Agricultural Students, First Year.

Three exercises per week. 1st S.

32. Grammar and Composition.

This is a continuation of Course 31. For Two Year Agricultural Students, First Year.

Open only to students who have completed Course 31.

Three exercises per week. 2nd S.

FORESTRY.

31. Farm Forestry.

Method of reproduction, seed collecting, thinning, determination of heights, contents and increment of forest trees. For Two Year Agricultural Students, First Year.

Two exercises per week. 2nd S.

32. Arboriculture and Forestry.

Elective for Two Year Agricultural Students, Second Year.

Three exercises per week. 2nd S.

HORTICULTURE.

31. Vegetable Gardening.

A study of the commercial methods of vegetable growing. Special attention is given to the home garden. For Two Year Agricultural Students, First Year.

Three exercises per week. 1st S.

32. Fruit Growing.

This course embraces a study of commercial orcharding; each fruit being studied with reference to planting, cultivating, pruning, fertilizing, picking, packing, storing and marketing. For Two Year Agricultural Students, Second Year.

Three exercises per week. 1st S.

33. Plant Growth and Greenhouse.

Combined lecture, demonstration and laboratory course in plant growth and greenhouse management. Elective for Two Year Agricultural Students, Second Year.

Three exercises per week. 1st S.

34. Home Decoration.

A study of ornamental trees, shrubs and flowers; their culture, proper arrangement and decorative value, with special reference to home surroundings. Elective for Two Year Agricultural Students, Second Year.

Three exercises per week. 2nd S.

MATHEMATICS.

MR. EASTMAN.

31. Arithmetic and Bookkeeping.

For Two Year Agricultural Students, First Year.

Three exercises per week. 1st S.

MILITARY SCIENCE AND TACTICS.

CAPT. HUNT.

1. Military Drill.

For Two Year Agricultural Students, First Year.

Two exercises per week. 1st S.

2. Military Drill.

For Two Year Agricultural Students, First Year.

Two exercises per week. 2nd S.

3. Military Drill.

For Two Year Agricultural Students, Second Year.

Two exercises per week. 1st S.

4. Military Drill.

For Two Year Agricultural Students, Second Year.

Two exercises per week. 2nd S.

9. Infantry Drill Regulations.

Practical instruction and lectures. For Two Year Agricultural Students, First Year.

One exercise per week. 1st S.

10. Manual of Guard Duty and Small Arms Firing Regulations.

For Two Year Agricultural Students, First Year.

One exercise per week. 2nd S.

17. Lectures on Advance Guards, Outposts, etc.

For Two Year Agricultural Students, Second Year.

One exercise per week. 1st S.

18. Lectures on Advance Guards, Outposts, etc.

Continuation of Course 17. For Two Year Agricultural Students, Second Year.

One exercise per week. 2nd S.

PHYSICS.

PROF. NESBIT.

31. Elementary Physics.

For Two Year Agricultural Students, Second Year.

Four exercises per week. 1st S.

SHOP WORK.

31. Wood Work. Mr. Ingham.

For Two Year Agricultural Students, First Year.

Two exercises per week. 2nd S.

32. Iron Work. Mr. Brown.

For two Year Agricultural Students, Second Year.

Two exercises per week. 2nd S.

ZOOLOGY.

31. Vertebrate Anatomy and Physiology.

The anatomy and physiology of the higher vertebrates based upon that of man and with special reference to domestic animals.

Recitations and laboratory dissections and experiments. For Two Year Agricultural Students, First Year.

Three exercises per week. 1st S.

32. Elementary Entomology.

The structure, habits and classification of insects, with special consideration of injurious pests and means of controlling them. For Two Year Agricultural Students, First Year.

Three exercises per week. 2nd S.

COURSES OF STUDY AND SCHEDULE OF HOURS.

First Year.

FIRST SEMESTER.

		Credit hours.
Agronomy 31	Elementary Agriculture	3
Botany 31	Elements of Botany	3
English 31	Grammar and Elementary Composition	3
Horticulture 31	Vegetable Gardening	3
Mathematics 31	Mathematics and Bookkeeping	3
Military Science 1	Drill	1
Military Science 9	Infantry Drill Regulations	1
Zoology 31	Vertebrate Anatomy and Physiology	3

SECOND SEMESTER.

Botany 32	Plant Diseases	3
Chemistry 31	Elementary Applications	2
Dairying 31	Milk and Milk Testing	3
English 32	Grammar and Composition	3
Forestry 31	Farm Forestry	2
Military Science 2	Drill	1
Military Science 10	Manual of Guard Duty	1
Shop Work 31	Wood Work	2
Zoology 32	Economic Entomology	4

Second Year.

FIRST SEMESTER.

Agronomy 32	Farm Equipment and Farm Crops	3
An. Husb. 31	Breeds of Livestock	3

		Credit hours.
**An. Husb. 32*	Sheep Raising	3
**Dairying 32*	Butter Making	3
Drawing 31	....	1
Horticulture 32	Fruit Growing	3
**Horticulture 33*	Plant Growth and Greenhouse...	3
Military Science 3	Drill	1
Military Science 17	Advance Guards, Outposts, etc...	1
Physics 31	Elementary Physics	4

SECOND SEMESTER.

Agronomy 33	Soils and Soil Physics..........	3
Agronomy 34	Manures and Fertilizers........	2
An. Husb. 33	Feeds and Feeding	3
**An. Husb. 34*	Animal Breeding	3
**An. Husb. 35*	Veterinary Science	3
**An. Husb. 36*	Poultry	2
**Dairying 33*	Technology of Milk	2
**Forestry 32*	Arboriculture and Forestry.....	3
Horticulture 34	Home Decoration	3
Military Science 4	Drill	1
Military Science 18	Advance Guards, Outposts, etc...	1
Shop Work 32	Iron Work	2

*Elective. Elect any one or two.

TWO YEAR COURSE IN AGRICULTURE—FIRST YEAR.

	Day	8–9	9–10	10–11	11–12	P. M.
FIRST SEMESTER	Monday	English 31	Agronomy 31	†Mathematics 31	†Military Sci. 1	Horticulture 31
	Tuesday		Military Sci. 9	Horticulture 31	Botany 31	Zoology 31
	Wednesday	English 31	Agronomy 31	Mathematics 31	Zoology 31	Botany 31
	Thursday		Horticulture 31		Zoology 31	
	Friday	English 31	Agronomy 31	†Mathematics 31	†Military Sci. 1	Botany 31
	Saturday					
SECOND SEMESTER	Monday	English 32	Chemistry 31	†Forestry 31	†Military Sci. 2.	Botany 32
	Tuesday	Shop 31	Shop 31	Shop 31	Shop 31	Zoology 32
	Wednesday	English 32	Chemistry 31		Zoology 32	Forestry 31
	Thursday	Dairying 31	Dairying 31	Dairying 31	Botany 32	Zoology 32
	Friday	English 32	Military Sci. 10	†Dairying 31	†Military Sci. 2	Botany 32
	Saturday	Dairying 31	Dairying 31	Dairying 31	Zoology 32	

†These periods are transposed from December 1 to March 31.

TWO YEAR COURSE IN AGRICULTURE—SECOND YEAR

	DAY	8–9	9–10	10–11	11–12	P. M.
FIRST SEMESTER	Monday	An. Husb. 32 *Horticulture 33	Horticulture 32	†*Dairying 32	†Military Sci. 3	An. Husb. 31
	Tuesday	*Dairying 32	*Dairying 32	Agronomy 32	Physics 31	*Horticulture 33
	Wednesday	*Horticulture 33	Horticulture 32	An. Husb. 31	Physics 31	Agronomy 32
	Thursday	*An. Husb. 32	*An. Husb. 32	Agronomy 32	Physics 31	Drawing 31
	Friday	Military Sci. 17	*An. Husb. 32	†An. Husb. 31	†Military Sci. 3	Horticulture 32
	Saturday	*Dairying 32	*Dairying 32	*Dairying 32	Physics 31	
SECOND SEMESTER	Monday	Agronomy 34	*An. Husb. 35	†Agronomy 33	†Military Sci. 4	*Forestry 32 *An. Husb. 36
	Tuesday	Military Sci. 18	*An. Husb. 34	Agronomy 33		*Dairying 33
	Wednesday	Agronomy 34	*An. Husb. 35 *Horticulture 34		*Forestry 32	Agronomy 33
	Thursday	Shop 32	Shop 32	Shop 32	Shop 32	An. Husb. 33
	Friday	An. Husb. 33	*Horticulture 34 *An. Husb. 34	†	†Military Sci. 4	*Horticulture 34 *An. Husb. 35
	Saturday	An. Husb. 33	*Dairying 33 *An. Husb. 34	*Dairying 33	*Forestry 32 *An. Husb. 36	

* Elective.

†These periods are transposed from December 1 to March 31.

TEN WEEK COURSE IN DAIRYING OR DAIRY SCHOOL.

OPENING.

The Fourteenth Annual Dairy School of the New Hampshire College opens Tuesday, January 5, and closes Friday, March 13. Students should present themselves for registration at Thompson Hall the first day of the session. Lectures and laboratory work begin the following day.

ADMISSION.

The school is open to men and women sixteen years of age and upward. No entrance examination is required. However, in order to make the best use of the instruction, the student should have a good common school education. The experiences of previous years have shown that the subect in which the student is most deficient is arithmetic, especially percentage and decimals. Both of these divisions of arithmetic are used to a large extent in solving problems in the creamery and also in computing rations for the dairy cow. It is therefore well for those planning to take the dairy course to review these subjects before entering. To be most benefited by the school, the students should have had some practical experience on a farm or in a creamery.

EXPENSES.

A tuition fee of five dollars is payable on registering at the beginning of the term; other expenses, including books, white suits, and room and board for ten weeks, amount to approximately sixty dollars.

CERTIFICATES.

Students completing the required work of the dairy school, and passing satisfactory examinations, will be given certificates.

DESCRIPTION OF SUBJECTS.

Associate Professor W. H. PEW.

Agriculture 42. Breeds of Dairy Cattle.

Lectures and recitations upon the origin, history, distribution, characteristics, adaptability and standard of excellence of the pedigreed breeds of cattle, with special reference to the selection

of breeds and individual animals for the herd. This subject will be studied four hours per week for the first five weeks. The practical work will consist of scoring and judging representatives of the various breeds of dairy cattle, and in tracing pedigrees of animals in the herd books of the different breeds.

Professor FRED W. MORSE.

Agriculture 43. Chemistry of Dairy Products.

The subject is taken up in a course of eight lectures, illustrated by experiments and specimens, and includes the properties and separation of the different constituents of milk, fat, casein, albumen, sugar, etc., the composition of butter and butter-fat, and the properties and effects of preservatives.

Associate Professor W. H. PEW.

Agriculture 44. Diseases of Cattle.

This course will consist of eight lectures and recitations upon the anatomy and physiology of the cow, with special reference to the digestive, reproductive and milk-producing organs. The common diseases, their causes and the methods of treatment will be discussed.

Agriculture 45. Feeds and Feeding.

Lectures and recitations upon the composition and digestibility of feeding stuffs, the preservation of coarse fodders, the making and feeding of ensilage, and the grinding, steaming and cooking of feed. A careful study will be made of the different grains and feeds, and their value in a ration for dairy cows. Practice will be given in computing rations for the dairy cow.

Professor F. W. TAYLOR.

Agriculture 50. Forage and Silage Crops.

This course will consist of ten lectures upon forage and silage crops which are suited for New Hampshire conditions. The matter of varieties, preparation of the ground, time of seeding, amount of seed, harvesting and storing will be discussed. Soiling crops, the construction of silos and the growing of crops for the silo will be treated in as much detail as the time allows.

Associate Professor FRED RASMUSSEN.

Dairying 40. Butter Making.

Lectures and recitations on the different systems of creaming milk and a comparison of the efficiency of different cream separ-

ators under varying conditions; cream ripening, churning, washing, marketing and scoring of butter.

Dairying 41. Dairy Bacteriology.

Lectures and demonstrations on the functions of bacteria and the application of bacteriological principles to dairy work, such as pasteurization, cream ripening, commercial starters, and deterioration of butter.

Dairying 42. Dairy Laboratory.

The equipment in the dairy building is such that the laboratory work can be made applicable both to farm and factory conditions. The student will have an opportunity to study construction and efficiency, and operation of the various machines used in the handling of milk and making of butter. The use of the Babcock test in apportioning the money value of milk is now regulated by state law, and the importance of the test in the successful management of the dairy herd has created a demand for more complete and practical training. The details of the test will be studied carefully, and the student will practice testing milk, cream, skim-milk and butter-milk until fully competent to perform the work for himself or for others.

Dairying 44. Milk and Milk Testing.

This course will consist of the study of secretion, the physical and chemical properties of milk; the production and preparation of sanitary, certified and modified milk, the various methods of sampling and testing milk and cream, and the detection of adulterants and preservatives.

Mechanical Engineering 40. Boilers and Engines.

Lectures will be given on the construction, operation and care of boilers, motors, steam and gasoline engines. The lectures will be followed by practical demonstration and practice in the management of the various motive powers. Instruction and practice will also be given in pipe cutting and fitting, and other work incidental to the management of a steam plant. The course will consist of a two-hour period once a week for the ten weeks.

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION.

Most of the Agricultural Experiment Stations of the various states, including that of New Hampshire were founded in 1888 by an act of Congress, approved March 2, 1887, known as the

Hatch Act in honor of its author. This act appropriated fifteen thousand dollars ($15,000) annually for the maintenance of an Agricultural Experiment Station in each state. This act provides—

"That it shall be the object and duty of said Experiment Stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural and artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective states and territories." The act also provides that the results of such work shall be published in bulletins and reports.

A further endowment of the Experiment Stations to provide specifically for research work was made by the Adams Act passed by Congress and approved March 16, 1906, which provided an increased annual appropriation which amounts to $11,000 for the current fiscal year and increases to $15,000 in 1911-'12. This appropriation is specifically limited to the "necessary expenses of conducting original researches or experiments," and the rulings of the U. S. Department of Agriculture, which is vested with the supervision of the expenditures under this act, require that this appropriation be spent in fundamental investigations or researches to determine the underlying causes and principles of agricultural science, rather than for mere experiments to secure results of immediate practical application as contemplated under the Hatch Act Appropriation. The purposes of the two acts are therefore supplementary but distinct.

The New Hampshire Agricultural Experiment Station is organized as a department of the New Hampshire College of Agriculture and Mechanic Arts, and is administered by a Board of Control, elected by its Board of Trustees.

The publications of the station comprise 139 bulletins of the regular series and seven circulars. The bulletins are issued at irregular intervals and are sent to all residents of New Hampshire requesting them. Back numbers will be sent as long as the supply lasts.

The station is prepared to give advice and assistance to the farmers of New Hampshire along the following lines:

The maintenance of soil fertility, including the rotation of crops and the selection and use of manures and fertilizing materials.

The selection of varieties of grains, grasses and forage crops and methods of culture.

The selection of varieties of fruits and vegetables and the management of orchards.

The examination of seeds that are suspected of being unsound or adulterated; the identification of grasses, weeds and other plants; the prevention of fungous diseases of plants.

The identification of insects and the control of such as are injurious.

The feeding of animals, including calculation of rations and use of various feeding stuffs.

The methods of milk production, creamery and dairy methods and machinery and the scoring of dairy products.

The testing of milk to determine the value of dairy cows.

The planting and care of forest trees and the management of farm wood lots.

Any citizen of New Hampshire has the right to apply to the station for such assistance as it can give, and all such requests will be given prompt attention.

COMMENCEMENT 1908.

On Commencement Day, June 3, 1908, the following degrees were conferred:

BACHELORS OF SCIENCE.

Agriculture.

Carlisle, Lawrence A., Exeter.
Farwell, Oren L., Chesham.
Sanborn, Moses H., Fremont.
Waite, George L., Dunbarton.

Chemistry.

Evans, Walter W., E. Kingston.
French, Harry F., Plymouth.
Perley, George A., Goffstown.

Electrical Engineering.

Barton, Arthur Hosea, Newport.
Batchelder, Arthur M., Suncook.
Buss, Minot G., Wilton.
Clough, Francis, Contoocook.
Cone, Charles F., Nashua.
Cory, Merton M., Nashua.
Huse, Merrit C., Concord.
O'Connor, John J., Portsmouth.
Priest, James H., Manchester.
Walker, Harold D., Kittery, Maine.

General.

Chesley, Mary C., Durham.
DeMeritt, Katharine, Durham.
Page, John C., Dover.
Pettee, Sarah E., Durham.

Mechanical Engineering.

Croghan, John T., Concord.
Kirkpatrick, William R., Nashua.
Smalley, Dean F., Walpole.
Tarbell, Carl B., Milton.
Wadleigh, Ray E., Kensington.

Unclassified.

Adams, Waldo L., Townsend, Mass.
Cash, James D., Massabesic.
Hill, Stanley F., Nashua.
Woodman, Francis W., W. Derry.

Certificates.

Holmes, George A., Langdon.
Leavitt, Guy, Sanbornton.
Littlefield, Harold T., Salem Depot.

PRIZE RECORD FOR 1908.

BAILEY PRIZE—$10.

Given by Dr. C. H. Bailey of the Class of '79, and E. A. Bailey of the Class of '85.

George Arthur Perley, Goffstown.

ERSKINE MASON MEMORIAL PRIZE.

George Arthur Perley, Goffstown.

SENIOR STANDING HIGHEST IN THE MILITARY DEPARTMENT.

John Timothy Croghan, Concord.

WINNERS OF INDIVIDUAL PRIZE DRILL.

GOLD MEDAL.

John Worthen Davis, '11, Concord.

SILVER MEDAL.

Charles F. Whittemore, '11, Pembroke.

HONORABLE MENTION.

Charles Hubert Locke, '11, Wakefield, Mass.

PRIZE SWORD—EXCELLENCE IN DRILL.

Harold Hartshorn Wilkins, '09, Amherst.

HONORABLE MENTION.

Carl Duncan Kennedy, '09, Concord.

SENIORS REPORTED TO ADJT.-GENERAL, U. S. ARMY, FOR APTITUDE IN DRILL.

John Timothy Crogan, Concord.
Merritt Chase Huse, Concord.
Harold Duncan Walker, Kittery, Me.

COLOR COMPANY—FALL TERM.

Company B.

VALENTINE SMITH SCHOLARSHIPS.

William S. Campbell, '09.
Edward D. French, '10.
Earle B. Jennings, '11.
Philip L. Gowen, '12.

ROSTER OF BATTALION.

For 1908—'09.

COMMANDANT.

Captain William E. Hunt, Twenty-Second U. S. **Infantry.**

CADET OFFICERS.

Major C. D. Kennedy.
First Lieut. and Adjt. L. S. Morrison.
First Lieut. and Q. M. H. E. Wilder.
Sergt. Maj. C. S. Wright.
Q. M. Sergt. H. P. Corliss.
Color Sergt. C. E. Lawrence.
Drum Major W. F. Langelier.

COMPANY A.

Capt. H. H. Wilkins,
1st Lt. R. A. Neal.
2nd Lt. J. M. Leonard.

COMPANY B.

Capt. L. L. Smalley.
1st Lt. C. Chase.
2nd Lt. H. P. Corson.

COMPANY C.

Capt. L. A. Pratt.
1st Lt. F. O. Chase.
2nd Lt. A. E. Blake.

FIRST SERGEANTS.

E. H. Burroughs.
O. F. Bryant.
H. C. Read.

SERGEANTS.

C. L. Perkins.
G. B. Hefler.
C. H. Swan.
S. T. Hoyt.
L. H. Burns.
D. W. Anderson.
W. W. Burroughs.
E. D. French.
H. W. Neal.
B. W. Proud.
H. T. Converse.
G. H. Chamberlin.

CORPORALS.

J. H. Bachelder.
P. J. Burbeck.
R. E. Carpenter.
L. E. Pierce.
C. F. Whittemore.
F. G. Fisher.
B. F. Proud.
L. W. Bennett.
E. E. Stark.
J. W. Davis.
C. W. Kemp.
W. H. Quimby.

MUSICIANS.

H. W. Tenney. W. D. Kidder.
D. Boynton.

BAND.

1st Lt. J. P. Trickey.
Sergeant O. D. Goodwin.
Sergeant P. F. Ellsworth.
Sergeant J. E. Parker.
Sergeant C. S. Richardson.
Corporal C. W. Kelley.
Corporal S. N. Wentworth.
Corporal W. Morrill.

STUDENTS.

a—Agricultural Course; *c*—Course in Technical Chemistry; *g*—General Course; *m e*—Mechanical Engineering; *e e*—Electrical Engineering; *u*—Unclassified. Freshmen in the Engineering Courses are designated by *e* only.

GRADUATE.

Name.	Residence.
Hayes, Warren Chauncey	*Durham.*

SENIORS.

Name.	Residence.
Ackerman, Lawrence Day *c*	*Bristol.*
Brown, Edna Olive *g*	*Rye Beach.*
Campbell, William Smith *e e*	*Litchfield.*
Doe, Marion *g*	*Durham.*
Ellsworth, Perry Foss *e e*	*Meredith.*
Falconer, John Ironside *a*	*Milford.*
Fellows, Ernest Roslyn *e e*	*Exeter.*
Goodwin, Otis Dana *e e*	*Hollis.*
Kelley, Charles William *m e*	*Barnstead.*
Kennedy, Carl Duncan *c*	*Concord.*
Lougee, Bernard Ayers *e e*	*Pittsfield.*
McKone, Frank E. *e e*	*Dover.*
Merrill, Maurice David *e e*	*Andover.*
Parker, John Edward *a*	*Goffstown.*
Peaslee, Albert *m e*	*Gonic.*
Pike, Herbert Samuel *m e*	*Lisbon.*
Pratt, Lester Albert *c*	*Alton Bay.*
Quimby, Harold Wallace *m e*	*Northwood Narrows.*
Richardson, Charles Sidney *m e*	*Cornish Center.*
Sargent, George Jackman *c*	*Concord.*
Smalley, Lee Lawrence *m e*	*Walpole.*
Stevens, Ernest Morton *m e*	*Andover.*
Stokes, Iva Dorothy *g*	*Epsom.*
Townsend, Harry Storrs *a*	*Lebanon.*
Wendell, Chester Snell *e e*	*Dover.*
Wilder, Howard Erwin *m e*	*Amesbury, Mass.*
Wilkins, Harold Hartshorn *m e*	*Amherst.*
Woods, Arthur Page *m e*	*Bath.*

JUNIORS.

Name.	Residence.
Anderson, David Wadsworth *a*	*Manchester.*
Batchelder, Henry Edward *m e*	*Exeter.*
Bills, Frank Hartwell *e e*	*Reed's Ferry.*
Blake, Alfred Edward *c*	*Nashua.*
Boynton, Dalton *e e*	*Little Boar's Head.*
Bryant, Orville Frank *c*	*Ashland.*
Burroughs, Edgar Herbert *m e*	*Sanbornville.*
Burroughs, Wilbur Warren *m e*	*Sanbornville.*
Chamberlin, George H. *e e*	*Woodsville.*
Chase, Fred Odell *m e*	*Warner.*
Converse, Henry *a*	*Amherst.*
Corliss, Harry Percival *c*	*Wolfeboro.*
Corson, Harry Peach *c*	*Laconia.*
Drew, Lucy Abby *g*	*Colebrook.*
Emery, Roland Chester *e e*	*Hampton.*
French, Edward Daniel *e e*	*So. Hampton.*
Hefler, George Burpee, *m e*	*Jackson.*
Hoyt, Simes Thurston *m e*	*Newington.*
Langelier, Wilfred F. *c*	*Nashua.*
Lawrence, Cheney E. *m e*	*Nashua.*
Leonard, James Mortimer *e e*	*Woodsville.*
Morrison, Leonard S. *g*	*Penacook.*
Neal, Haldimand W. *e e*	*Dover.*
Neal, Robert A. *e e*	*Dover.*
Peel, Charles Edward *c*	*Nashua.*
Perkins, Clement Linwood *c*	*Berwick, Me.*
Read, Harold Clifford *e e*	*Westport.*
Sanborn, Edson Dana *a*	*Fremont.*
Scammon, Raymond Brewster *m e*	*Stratham.*
Thorp, Theron A. *e e*	*Exeter.*
Trickey, John Paul *c*	*Rochester.*
Wells, Burleigh Ray *e e*	*Somersworth.*
Wood, Chester Loring *u*	*Dudley, Mass.*

SOPHOMORES.

Name.	Residence.
Abbott, Harold Vincent *m e*	*Derry.*
Arozian, Ohannes A. *c*	*Nashua.*
Bachelder, John Hutchins *a*	*Concord.*
Bennett, Leland Wilson *e e*	*Laconia.*
Brackett, Thomas James *a*	*Greenland.*
Brown, Albert H. *a*	*Strafford.*
Brown, Charles O. *c*	*Concord.*
Burbeck, Perry James *e e*	*Haverhill.*
Burns, Lucian H. *a*	*Milford.*
Carpenter, Roy Elbert *e e*	*Medford, Mass.*
Chase, Carl *g*	*Webster.*
Clark, Maurice C. *m e*	*Marlboro.*
Colby, Arthur S. *a*	*Tilton.*
Cotton, Arthur Clyde *g*	*Alton.*
Davis, John Worthen *m e*	*Concord.*

Name.	Residence.
DeMerritt, Margaret *g*	*Durham.*
Drew, Mariette Alice *g*	*Colebrook.*
Easterbrook, Ralph Lewis *a*	*Dudley, Mass.*
Fisher, Frank Gordon *a*	*Woburn, Mass.*
Gaddas, Sumner Felt *e e*	*Hillsboro.*
Gove, Willis Ansel *m e*	*Laconia.*
Hammond, Roland Bowman *g*	*Nashua.*
Hardy, Harold Elwin *a*	*Hollis.*
Hatch, Olive Estelle *g*	*Dover.*
Holmes, Harry Wesley *e e*	*Northwood.*
Jennings, Earle B. *e e*	*Winchester.*
Judkins, Henry Forrest *a*	*Kingston.*
Kemp, Charles W. *a*	*Kingston.*
Kennedy, Frank Paul *g*	*Dover.*
Kidder, Walter Dennis *e e*	*Manchester.*
Little, Webb *g*	*Compton.*
McLucas, Charles Abraham *m e*	*Nashua.*
Morrill, Frank Whitcomb *g*	*Walpole.*
Morrill, Winfred *m e*	*Pike.*
Nason, Carl Eastman *e e*	*Concord.*
Parker, Edward Gookin *c*	*Portsmouth.*
Parker, William Folger *e e*	*Goffstown.*
Pease, Bret *e e*	*Ashland.*
Philbrook, Henry Brown *g*	*No. Hampton.*
Pierce, Leonard Emerson *e e*	*Worcester, Mass.*
Proud, Benjamin Franklin *m e*	*Manchester.*
Proud, Brenton W. *e e*	*Manchester.*
Quimby, Waldo Hutchinson *e*	*Concord.*
Reynolds, Clearton Howard *c*	*Middletown, N. Y.*
Roberts, George Filmore *a*	*Alton.*
Robinson, Charles Harrison *c*	*Marlboro.*
Scott, Bessie Amanda *g*	*Tyson, Vt.*
Stark, Eldon Eugene *e e*	*Haverhill.*
Swan, Clyde Henry *g*	*Keene.*
Tenney, Harry William *e e*	*Newport.*
Towne, Ernest George *m e*	*Thornton.*
Tucker, James William *g*	*Concord.*
Wentworth, Stephen Neal *g*	*Rochester.*
Whittemore, Charles F. *c*	*Pembroke.*
Wilkins, Aaron Wallace *m e*	*Amherst.*
Wilkins, Carroll Blaisdell *g*	*Nashua.*
Wright, Charles Shannon *a*	*Portsmouth.*
Wyman, Horace Chester *a*	*Manchester.*

FRESHMEN.

Name.	Residence.
Bailey, Thomas Craig *e*	*New Boston.*
Batchelder Roy Eugene *e*	*Sugar Hill.*
Bates, Everett Heath *e*	*Dudley, Mass.*
Berry, George Wesley *a*	*Stratham.*
Bradford, Maurice P. *e*	*Derry.*
Brown, Milward W. *e*	*Hillsboro.*

Name.	Residence.
Buckminster, Paul D. *e*	*Haverhill, Mass.*
Bunker, Lewis L. H. *e*	*Durham.*
Casci, Alfred J. *e*	*Concord.*
Catlin, Harwood B. *e*	*Hill.*
Chamberlain, Walter E. *a*	*Sugar Hill.*
Chase, Earle H. *e*	*Newport.*
Chase, William Hosea *e*	*Newport.*
Cole, Florence Viola *g*	*Dover.*
Davis, Arthur G. *a*	*Peterboro.*
Davison, Frank S. *a*	*Durham.*
DeMerritt, Stephen *e*	*Durham.*
Donnelly, Edith G. *g*	*Dover.*
Drake, George Lincoln *e*	*Antrim.*
Duncan, Raymond C. *e*	*Alton.*
Eastman, Wesley Edward *a*	*E. Andover.*
Foster, Leland S. *e*	*Newport.*
Garland, John A. *a*	*Hampstead.*
Gowen, Philip Lewis *e*	*Stratham.*
Harding, Daniel Pearl *g*	*New Durham.*
Hargraves, Fred Forest *e*	*Nashua.*
Hayes, Bernice M. *g*	*Durham.*
Hoben, Frank M. *c*	*Concord.*
Holden, H. Chester *e*	*Manchester.*
Hood, Leslie Newton *e*	*Nashua.*
Hooke, Lyman S. *a*	*Fremont.*
Huse, Oscar E. *a*	*Newton Junction.*
Johnson, Maurice Lingard *g*	*Nashua.*
Knight, Ray H. *a*	*Marlboro.*
Leighton, Alan *g*	*Concord.*
Leighton, Arthur John *e*	*Laconia.*
Lovell, Roscoe Ernest *e*	*Portsmouth.*
Lowd, Clarence Mortimer *e*	*Clinton, Mass.*
McPheters, George A. *e*	*Portsmouth.*
Manter, Jerauld A. *e*	*Manchester.*
Merrill, Karl E. *e*	*Hudson.*
Morgan, Ralph Clifford *e*	*Concord.*
Neal, Cecil Maurice *e*	*Portsmouth.*
O'Malley, Michael J. *e*	*Somersworth.*
Page, William E. *e*	*Haverhill.*
Parker, Harry Stinson *e*	*Goffstown.*
Payne, Chauncey W. *e*	*Hill.*
Perkins, Harold Wilbur *e*	*Dover.*
Perkins, Irving C. *e*	*Kennebunkport, Me.*
Pettingill, James B. *e*	*Dover.*
Phillips, Paul Milton *a*	*Nashua.*
Reynolds, Roland E. *e*	*W. Upton, Mass.*
Riley, Martin E. *e*	*Somersworth.*
Robinson, John E. *e*	*Pembroke.*
Rogers, William Edward *e*	*Medford, Mass.*
Sawyer, Arthur H. *a*	*Atkinson.*
Sawyer, Howard Symmes *e*	*Woodstock.*
Scott, Charles Field *g*	*Durham.*

Name.	Residence.
Shapleigh, Edward Eugene *e*	*Kittery, Me.*
Shaw, Wyman Robinson *a*	*Strafford.*
Skinner, Russell E. *a*	*Colebrook.*
Smart, Guy *e*	*Rochester.*
Stevens, Ernest C. *a*	*Buffalo, N. Y.*
Sughrue, Timothy G. *g*	*Nashua.*
Tappan, Albert D. *e*	*North Woodstock.*
Taylor, Alexander *a*	*Bedford.*
Thompson, Ruth E. *g*	*Durham.*
Towle George Wesley *e*	*Newmarket.*
Tucker, Herbert R. *g*	*Concord.*
Tucker, Raymond Hodgdon *e*	*Berlin.*
Tuttle, Harry Benjamin *a*	*Atkinson.*
Waldron, Jeremy R. *e*	*Farmington.*
Warner, William Pearl	*Plaistow.*
Watson, Myles S. *a*	*Durham.*
Whittemore, Hollie L. *e*	*Colebrook.*
Wood, Arthur G. *e*	*Atkinson.*

TWO YEAR COURSE.

Second Year.

Name.	Residence.
Colburn, Luther Dodge	*New Boston.*
Barber, Frank W.	*Durham.*
Hill, Claudian F.	*Wakefield.*
Martin, Leslie Chapin	*Chicopee, Mass.*
Melkonian, James	*Alton.*
Townsend, Hugh	*Lebanon.*
Waite, Iru Merrill	*Goffstown.*
Wheeler, Harry F.	*Salem Depot.*

First Year.

Avery, Walter J.	*Laconia.*
Benner, Andrew W.	*Gonic.*
Bickford, Channing M.	*Rye Beach.*
Buffum, Warren Hodgdon	*Winchester.*
Gilman, Daniel E.	*Exeter.*
Harvey, Vernon C.	*Antrim.*
Hill, Ernest C.	*Strafford.*
Osgood, Wilfred Albro	*Windham Depot.*
Sanborn, Howard W.	*Sanbornton.*
Silver, Bertram E. G.	*Roxbury, Mass.*
Snow, Percy S.	*Nashua.*
Stevens, Henry L.	*Franklin.*
Wallis, William E., Jr.	*Littleton.*
Wheeler, Earle O.	*Weirs.*
Williams, Everett C.	*Worcester, Mass.*
Wiswell, Everett	*Colebrook.*
Woods, Minot W.	*Bath.*

SPECIAL COURSE.

Name.	Residence.
Abbott, Walter Sidney	*Manchester.*
Thomas, Edna	*Thomaston, Conn.*

TEN WEEK COURSE.

Brown, Perley William	*Chester, Vt.*
Cady, Burton Frederic	*Medford, Mass.*
Crockett, Henry Charles	*New London.*
Lane, Oliver Martin	*Keene.*
Rollins, Herbert William	*Concord.*
Stevens, Henry Lee	*Franklin.*
Wheeler, William John	*Antrim.*
Woodbury, F. P.	*Newburyport, Mass.*

SUMMARY.

Graduate	1
Seniors	28
Juniors	33
Sophomores	58
Freshmen	76
Students in Ten Week Course	8
Students in Two Year Course	25
Special Students	2
Total	231

REGISTER OF GRADUATES

NOTE.—The arrangement is: (*a*) Name in full. (*b*) Later degrees taken. (*c*) Residence at time of entering college. (*d*) Occupation, etc. (*e*) Present residence. *Dead. †Present address unknown. Graduates are earnestly requested to inform the registrar of any changes that should be made in this list.

DOCTOR OF SCIENCE.

Ned Dearborn, D. Sc., 1901. Asst. Curator of Birds, Field Museum of Natural History. *Chicago, Ill.*

MASTER OF SCIENCE.

Albert Conradi, M. S., 1902. B. Sc., (Ag.) O. S. U., 1901. Prof. of Zoology and Entomology, Clemson Agricultural College, *Clemson, S. C.*

John L. Randall, M. S., 1906. See class of 1905.

William O. Robinson, M. S., 1906. See class of 1905

Lewis H. Kenney, M. E., 1906. See class of 1899.

John D. Clark, M. S., 1907. See class of 1906.

BACHELORS OF SCIENCE.

1871.

William Preston Ballard, Concord. Farmer.
R. F. D., Route 1, Concord.

Lewis Perkins. Hampton. Retired. *Hampton.*

Charles Henry Sanders, Penacook. Merchant. *Main St., Penacook.*

3—

1872.

Edwin Bartlett, Bath. Farmer. *Spearville. Ford Co., Kansas.*

Frank Alexander White, Bow. Surveyor, Farmer.
Route 4, Concord.

2—

1873.

†Frederick Erasmus Eldredge, Kensington,

James Fred Smith. A. B., A. M., Dartmouth, 1885; A. M.. Stanford, 1900. Principal of High School.
43 McCoy Ave., Campbell, Cal.

Charles Henry Tucker, Plaistow. Woodworker.
24 Highland St., Amesbury, Mass.

3—

1874.

Millard Fillmore Hardy, Rev., Nelson. Graduated Theo. Inst., Ct., 1878. Clergyman. *East Jaffrey.*

*Henry Abbott Sawyer, North Weare.

2—*1

1875.

Walton Herman Aldrich, M. D., Univ. N. Y. City. 1880; Troy. Physician and Surgeon. *Marlborough.*

†Frank Pierce Curtis. Grocer. *Fitchburg, Mass.*

Frank Veranus Emerson. Lebanon. Manager Axe Mfg. Plant.
Masconia Terrace, East Lebanon.

Charles Webster Hardy, M. D.. Mo. Med. Coll., 1881; Marlboro. Physician and Surgeon. *201 So. Main St., Ottawa, Kansas.*

Harvey Jewell, Winchester. Fruit Grower and Poultryman.
R. F. D. 1, Cromwell, Conn.

*Charles Ormille Leavitt, Lebanon.

*John Loney McGregor, D. D. S., Phila. Dental Coll., 1877, M. D. Dartmouth, 1883; Whitefield.

Eliel Peck, Lebanon, Postmaster.
Kimball, Stearns County, Minn.

Ira William Ramsey, Walpole. *Walpole.*

Orlando Leslie Seward, Keene. Artist. *287 Church St., Keene.*

Emery Mason Willard, Harrisville. Druggist, 15 Union Street, Boston, Mass. *109 Hewlett St., Roslindale, Mass.*

11—*3

1876.

Herbert Cyril Aldrich. Troy. Insurance and Real Estate. *329 West 4th St., Los Angeles, Cal.*

†Edmund Lawson Brigham, Jaffrey. Mechanic.

Joseph Warren Butterfield, Westmoreland. Farmer. *North Montpelier, Vt.*

Arthur French Chamberlain, Westmoreland. Partner and New York and Foreign Buyer, of Edson Keith & Co. *132 Michigan Ave., Chicago, Ill.*

Anson Ballard Cross, Holyoke, Mass. Contractor and Builder of Railroads. *Main St., Wilmington, Vt.*

Warren Webster Kimball, Troy. Merchant. *Troy.*

Daniel Deeth Parker, Fitzwilliam. With Heywood Bros. & Wakefield Co. *Box 56, Gardner, Mass.*

7—

1877.

Rollin Kirk Adair, Indian Territory. Retail Groceries. *Chelsea, Indian Ter.*

*Homer Brooks, M. D., N. Y. Hom. Med. Coll., 1881, Franconia.

John Washington Carson, Mont Vernon. Farmer and Land Surveyor. *Francestown.*

*Charles Otto Chubert, Troy.

*Charles Albert Edwards, LL. B., Univ. of Iowa, 1880; Keene.

*William Francis Flint, Richmond.

Clinton Camillus Hall, Westmoreland. Agt. New York Life Ins. Co. *East Westmoreland.*

John Goodrich Henry, M. D., Dartmouth, 1880; Chesterfield. Physician. *15 Pleasant St., Winchendon, Mass.*

*Charles Pitkin Hollister, North Montpelier, Vt.

George Mirick Holman, M. D., Fitchburg, Mass., Teacher. *334 Boylston St., Boston, Mass.*

Charles Appleton Hubbard, Troy. Treasurer United Fruit Company. *Board of Trade Building, 131 State St., Boston, Mass.*

Carlos Augustus Wheeler, East Calais, Vt. Bee Keeper and Farmer. *Bracken, Comal Co., Texas.*

Everard Whittemore, Fitzwilliam. Insurance and Real Estate. *14 River St., Hudson, Mass.*

13—*5

1878.

†Ezra Eastman Adams, Manchester.
*Elmer Kilburn, Marlow.
Charles Edward Record, Fitchburg, Mass. Contractor and Builder. *73 Green St., Leominster, Mass.*
3—*1

1879.

Charles Hardy Bailey, M. D., Dartmouth, 1881. Physician. *89 East Broadway, Gardner, Mass., Station A.*
Richard Clinton Chapin, Chicopee, Mass. With American Writing Paper Company. *Holyoke, Mass.*
*Lucius M. Cragin, Lempster.
*Nathaniel Cutler Holmes, Jaffrey.
Fred Charles Park, Lempster. Traveling Salesman. *6 Essex St., Concord.*
George Henry Wilkins, M. D., N. Y. Hom. Med. Coll., 1883; Amherst. Physician. *324 Walnut St., Newtonville, Mass.*
6—*2

1880.

Charles Harvey Hood, Derry. Milk Business. *2 Benton Road, Somerville, Mass.*
1—

1881.

Edwin Thompson Aldrich, Troy. General Insurance Agent. *Bridgman's Block, Keene.*
Henry Lyman Barnard, Troy. Clerk. *Troy.*
*George Jordan Boardman, Lawrence, Mass.
Edwin Franklin Bristol, Harwinton, Conn. Farmer. *Ascutneyville, Vt.*
Artemas Terald Burleigh, Farmer and Lumber Dealer. *Franklin.*
Frank Dana Ely, Cavendish, Vt. With Vermont Marble Company, Electrician. *6 School St., Proctor, Vt.*
Sanford Eugene Emery, LL. B., Albany Law School, 1886; Proctorsville, Vt. Attorney-at-Law. *Proctorsville, Vt.*
Charles Herbert Hazen, Hartford, Vt. Farmer and Market Gardener. *Bethlehem.*
Frank P. Marston, Hartford, Vt. Real Estate and Insurance. *46 Main St., Hudson, Mass.*
William Augustus Megrath, M. D., Dartmouth, 1886; Cavendish, Vt. Physician. *Loudon.*

Fred Townsend Stanton, Strafford. Farmer.
R. F. D. No. 1, Rochester.

Victor Hugo Stickney, M. D., Dartmouth, 1883; Tyson, Vt. Physician and Surgeon. *Dickinson, N. Dak.*

Samuel Austin Wallace, Ph. G., Boston School of Pharmacy, 1886; West Hartford, Vt. Druggist. *Crookston, Minn.*

George Herbert Whitcher, Strafford. Director of the New Hampshire Agricultural Experiment Station, February 22, 1888 to November 1, 1894; Professor of Agriculture of the New Hampshire College, June, 1887 to November 1, 1894. District Superintendent of Schools, August 1, 1900. *Berlin.*

14—*1

1882.

Harvey Lincoln Boutwell, LL. B., Boston University, 1886; Hopkinton. Attorney-at-Law, 209 Washington Street, Boston, Mass. *37 Pierce St., Malden, Mass.*

Dana Justin Bugbee, North Pomfret, Vt. Mining in Colorado.
North Pomfret, Vt.

*Robert Fletcher Burleigh, M. D., Dartmouth, 1887; Franklin.

La Forrest John Carpenter, Surry. Farmer.
R. F. D. No. 1, Shirley, Mass.

Edwin Preston Dewey, Hanover. City Engineer.
237 Olive Ave., Long Beach, Cal.

George Andrew Loveland, LL. B., University of New York, 1886, Norwich, Vt. Section Director United States Weather Bureau. *1130 So. 20th St., Lincoln, Neb.*

†John Wright Mason, Hanover.

Harlan Addison Nichols, M. D., Derry. Physician and Surgeon.
Care Montezuma Copper Co., Nacozari, Sonora, Mexico.

*Frank Elmer Thompson, Stark.

9—*2

1883.

Elmore Ferdinand Arnold, M. D., University City of New York, 1885; Londonderry, Vt. Physician.
902 Broadway, New York. N. Y.

Frank Landor Bigelow, Proctorsville, Vt. Instructor in Mathematics and Sciences, Goddard Seminary, Barre, Vt., 1883-1886. Business. *Rutland, Vt.*

Frederick Stocks Birtwhistle, Troy. Consulting and Supervising Electrical Engineer.
51 Tucker Bldg., Raleigh, N. C.

Noice D. Bristol, Harwinton, Conn. Photographer.
2665 Medary Ave., Columbus, O.

Frederick Plummer Comings, Lee. Trustee New Hampshire College, 1893-1903. *Lee.*

Frank Harry Follansbee, Canaan. Railway Postal Clerk.
41 Sharon St., West Medford, Mass.

Adams Clark French, M. D., D. O., Franklin Falls. Physician.
231 So. Hayne St., Chicago, Ill.

James Edgar Gay, Tunbridge, Vt. Woolen Manufacturer.
Cavendish, Vt.

Elmer Daniel Kelley, Franklin Falls. Farmer and Business.
445 Central St., Franklin Falls.

Alvah Benjamin Morgan, Canaan. Pharmacist, Stationer and Newsdealer. *Woodstock, Vt.*

William Lincoln Whittier, Deerfield. Foreman of Machine Shop.
121 Rantoul St., Beverly, Mass.

Charles Minot Woodward, Hanover. Teacher, Public Schools.
1620 College Ave., Fort Worth, Texas.

12—

1884.

*Ernest Smith Cummings, Lee.

Fred Carlos Davis, South Reading, Vt. Lawyer, Civil Engineer and Farmer. *123 South St., Springfield, Vt.*

Sylvester Miller Foster, Riverhead, N. Y. *Westport, Conn.*

Herbert Harvey Kimball, M. S., Columbian University, 1900, Hopkinton. Director of Research Work in Solar Radiation, U. S. Weather Bureau. *Washington, D. C.*

Moses Bisbee Mann, Benton. Inspector of Customs.
Custom House, Boston, Mass.

George Milton Moore, Plymouth, Vt. In private business.
Ludlow, Vt.

Ziba Amherst Norris, Lyme. Dealer in Groceries and Provisions, Wholesale and Retail, Dorchester and Cohasset.
587-593 Washington St., Dorchester, Mass.

Edwin Chapin Thompson, Lee. In charge Local Office.
Observation Bldg., LaCrosse, Wis.

8—*1

1885.

George Ellsworth Adams, Weston, Vt. Merchant.
Vernal, Utah.

Ruel Seabury Alden, Lyme. Superintendent of College Farm, 1895-'97. Superintendent Vermont Marble Company's Farms.
Proctor, Vt.

Walter Eugene Angier, C. E., Dartmouth, 1887; West Swanzey. Civil Engineer. *Office, 1750 Monadnock Block, Chicago, Ill.*

Edward Alonzo Bailey, West Swanzey. Chair Maker.
55 Pine St., Keene.

†Phillips Greenleaf Bickford, Lyme.

Andrew Walter Brill, Riverhead, L. I. Clerk North British and Mercantile Fire Insurance Company, 76 Williams Street, New York, N. Y. *Hempstead, N. Y.*

†Paul Cuff Brooks, Boston, Mass.

Frank Jay Emerson, Epping. Civil Service, U. S. Govt.
Box 312, Portsmouth.

Allen Hazen, Wilder, Vt. Consulting Engineer.
103 Park Ave., Cor. 41 St., New York, N. Y.

George Mayo Mullins, Londonderry. Attorney-at-Law.
727 Symes Bldg., 16th and Champa St., Denver, Colo.

Albert Henry Wood, Lebanon. Associate Professor of Agriculture, 1890-'94. Grain Merchant. *Framingham, Mass.*

11—

1886.

Frank Albert Davis, M. B., M. D., Boston University School of Medicine, 1897, 1898; South Lee. Physician.
Hotel Buckminster, Commonwealth Ave. and Beacon Sts. Boston, Mass.

James Ellsworth Harvey, Surry. Photographer.
51 North Main St., Concord.

Belezar Stoianoff Ruevsky, Tirnovo, Bulgarie. Maître au Gymnase de garçon du Government, Tirnovo, Bulgaria.
Termoro, Bulgaria.

Madison Templeton Thurber, M. D., Dartmouth, 1890, Webster. Physician. *85 Savin Hill Ave., Boston, Mass.*

Edward Hills Wason, New Boston. Attorney-at-Law.
142 Main St., Nashua.

George Pillsbury Wood, Lebanon. Draftsman in charge, Bureau of Yards and Docks, Navy Department.
3407 Holmead Place, N. W., Washington D. C.

6—

1887.

William Sprague Currier, Norwich, Vt. Local Forecaster U. S. Weather Bureau, *1631 Nicholas Bldg., Toledo, Ohio.*

Arthur Woodbury Hardy, C. E., Dartmouth, 1889; Hopkinton. Manager Western Sprinkler Risk Association. *240 La Salle St., Chicago, Ill.*

George Albert Sanborn, Rochester. Salesman. *34 Pine St., Rochester.*

Hiram Newton Savage, C. E., Dartmouth; White River Junction, Vt. Member Am. Soc. C. E.; Supervising and Consulting Engineer, U. S. Reclamation Service. *Huntley, Montana.*

Bion Leland Waldron, Strafford. Official in charge U. S. Weather Bureau. *Government Bldg., Hannibal, Mo.*

5—

1888.

*Melvin Burnside Carr, North Haverhill.

Herbert Grant Davis, South Lee. General Manager Sea View Railroad Company and Narragansett Pier Electric Light & Power Company. *Narragansett Pier, R. I.*

Edwin Chandler Gerrish, Webster. Assistant Paymaster and Long Distance Farmer. *66 Broadway, Lowell, Mass.*

†William Nelson Hazen, C. E., Dartmouth, 1890. Chief Draftsman for the Structural Iron and Steel Co., Bush Street and B. & O. R. R. *Pittsburg, Penn.*

Edward David O'Gara, Hanover. Farmer. *Hanover.*

George Elmer Porter, M. D., Dartmouth, 1892; Hartford, Vt. Physician and Chemist. *Warehouse Pt., Conn.*

George Jonathan Sargent, Canterbury. Civil Engineer and Contractor. *Canterbury.*

John Warren Smith, M. S., 1900; Grafton. Section Director U. S. Weather Bureau. *16 East Broad St., Columbus, Ohio.*

George Elwin Walker, Littleton. Farmer. *Littleton.*

8—*1

1889.

Fred Harvey Colby, Hopkinton. Fruit Grower. *Prosser, Wash.*

†Linwood Carroll Gillis.

*Louis Jerome Hutchinson, Norwich, Vt.

John Lawrence Norris, Lyme. Norris Brothers, Groceries and Provisions, 1673-1679 Washington Street, Boston; 529-535 Dudley Street, Roxbury; and 587-593 Washington Street, Dorchester, Mass. President of the Dairy Association Com-

pany, Lydonville, Vt.; Secretary and Treasurer of Photo Fabric Company of America. *6 Worcester Sq., Boston, Mass.*

Charles Walter Earl Scott, Winchester. Mechanic. *Darrington, Wash.*

David Elmer Stone, Hartford, Vt. Grain Merchant. *Framingham Center, Mass.*

Fred Washburne, West Springfield. With Sargent & Co., Foreman of Foundry Department. *56 Carmel St., New Haven, Conn.*

7—*1

1890.

John Young Jewett, C. E., Dartmouth, 1895; Gilford. Cement Expert, U. S. Reclamation Service. *Armour Institute, Chicago, Ill.*

†Joseph Franklin Preston, Hanover. Clerk. *Boston, Mass.*

Elihu Quinby Sanborn, Webster. Machinist. *Contoocook.*

Clarence Ira Slack, Norwich, Vt. Cashier. *51 North Market St., Boston, Mass.*

4—

1891.

Ernest Gowell Cole, Hampton. Postmaster and Merchant. *Hampton.*

Russell Marden Everett, Chester. Patent Lawyer and Solicitor. *788 Broad St., Newark, N. J.*

Edward Payson Stone, Canaan Center. Farmer. *Orford.*

3—

1892.

Percey Lovejoy Barker, C. E., Dartmouth, 1894; Milford. Supervisor of Bridges and Buildings, N. Y. C. & H. R. R. R. *Jersey Shore, Penn.*

Fred Driggs Fuller, Hanover. Chief Chemist, Pennsylvania Department of Agriculture. *State Capitol, Harrisburg, Penn.*

Arthur Benezette Hough, Lebanon. Dairy Farmer. *Lebanon.*

Edward Monroe Stone, C. E., Dartmouth, 1894; Marlborough. Architect and Engineer. *49 Pearl St., Hartford, Conn.*

4—

1893.

Wilton Everett Britton, Ph. D., Yale, 1903; Keene. State Entomologist and Entomologist of the Connecticut Agricultural

Experiment Station. *296 McKinley Ave., New Haven, Conn.*

Frank John Bryant, Enfield. Postoffice Clerk. *Lebanon.*

Charles Elbert Hewitt, M. M. E., Cornell, 1895; Hanover. Professor of Electrical Engineering, New Hampshire College. *Durham.*

Charles Lincoln Hubbard, M. E., 1895; Fitzwilliam. Consulting Engineer. *283 Central St., Auburndale, Mass.*

Orrin Moses James, Northwood. Civil Engineer State Highway Department. *Northwood Narrows.*

Arthur Whitmore Smith, M. Sc., Ph. D., Norwich, Vt. Assistant Professor of Physics, University of Michigan. *1008 Oakland Ave., Ann Arbor, Mich.*

6—

1894.

Bert Sargent Brown, Hanover. Farmer. *Hollis.*

Fred Willis Gunn, Keene. Machinist. *18 Huron St., Providence, R. I.*

Frederic William Howe, Hollis. Professor of Chemistry, Food and Dietetics, State Normal School, Framingham, Mass., Scientific Director Walker Gordon Laboratory Co., and Director of Food Laboratory, Boston Floating Hospital. *793 Boylston St., Boston, Mass.*

3—

1895.

Frank Stanley Adams, Gilsum. In office Vermont Farm Machine Company. *35 Atkinson St., Bellows Falls, Vt.*

Frank Clifton Britton, Keene. With the Sullivan Machinery Company of Claremont and Chicago (Cost-accounting Department). *7 Prospect St., Claremont.*

Henry Elmer Hill, Plainfield, Vt. With the Arizona Lumber Company. *Plainfield, Vt.*

Charles Arthur Trow, Mont Vernon. Chief Engineer in construction of Uba Railroad. *602 Rialto Bldg., San Francisco, Cal.*

4—

1896.

Lewis Harris Kittredge, Keene. President the Peerless Motor Car Company, *Overlook Road, East, Cleveland, Ohio.*

1—

1897.

Harlan Winfred Barney, Grafton. With Amoskeag Mfg. Co.
112 Myrtle St., Manchester.
Carrie Augustus Bartlett, Lee. Teacher. *Route 1, Newmarket.*
Mary Blaisdell Bartlett, (Mrs. I. A. Colby), Epping.
Ellwood City, Penn.
Walter French Buck, Manchester. Teacher.
129 W. Elm St., Brockton, Mass.
Arthur Willard Colburn, Dracut, Mass. Farmer. *Dracut, Mass.*
Carrie Lydia Comings, Durham. Teacher, Beverly High School.
28 Abbott St., Beverly, Mass.
Irving Lyford Dennett. Steam Engineer, Corn Products Refining Company. *Hudson Heights, N. J.*
*Mary Elizabeth Comings (Mrs. I. L. Dennett), Durham.
Elwin Henry Forristall, M. Sc., 1900, Columbia. Supt. Mass. Agricultural Coll. Farm. *Amherst, Mass.*
Leslie David Hayes, Durham. Instructor of Descriptive Geometry, Sibley College, Cornell University.
400 Stewart Ave., Ithaca, N. Y.
John Norton Hunt, Peterborough, *Peterborough.*
Ellery Dunbar Jenkins, Lee. Chemist, Lowell Fertilizer Company. *P. O. Box 105, Lowell, Mass.*
Woodruff Mason, Stamford, Conn. *Balenville, N. Y.*
Roscoe Hart Shaw, Milton. Dairy Expert, U. S. Department of Agriculture. *University of Missouri, Columbia, Mo.*
Charles William Vickery, Dover. With Claflin Brothers, Mining Engineers. *Nome City, Alaska.*
Delbert Amos Wheeler, South Ashburnham, Mass. Teacher.
Boston, Mass.
Everett Sidney Whittemore, Colebrook. Proprietor of North Conway Creamery. *North Conway.*
17—*1

1898.

*Richard Cole Butterfield, Westmoreland.
Helen Buzzell, (Mrs. Alexander McRae), Lee. *R. F. D., 5, Dover.*
Bernice Elisabeth Caverno (Mrs. E. H. Hancock), Durham.
Charlestown, Mass.
Burton Albert Corbett, Colebrook. Seed Potato Specialist and Breeder of Holstein-Friesian Cattle. *Colebrook.*
Alfred Caverly Durgin, Lee. Farmer and Fruit Grower.
R. F. D., Newmarket.

James Alfred Foord, Walpole. Professor of Farm Administration and Acting Head of the Div. of Agriculture, Massachusetts Agricultural College. *Amherst, Mass.*

John Williams Fullerton, Somersworth. Paymaster with Great Falls Woolen Company. *Somersworth.*

Arthur Given, Durham. Assistant Chemist, U. S. Department of Agriculture, Bureau of Chemistry. *1110 16th St., N. W., Washington, D. C.*

Edward Henry Hancock, Belmont. With C. H. Hood Co., Milk business. *Charlestown, Mass.*

Mabel Lucy Hayes, Durham. In charge of Commercial Dept. in High School. *5 Spring St., Newburyport, Mass.*

Tomokichi Hirokawa, B. S., Massachusetts Institute of Technology; Iamabari, Japan. Electrical Engineer, Kyoto Electric Light Company. *Kyoto, Japan.*

Harry Clinton Mathes, Newmarket. Inspector Penn., N. Y. & L. I. R. R. Co. *195 10th St., Long Island City, N. Y.*

Herbert Fisher Moore, M. E., Cornell, 1899; M. M. E., Cornell, 1903; Penacook. Assistant Professor of Theoretical and Applied Mechanics, University of Illinois. Member American Society of Testing Materials. *Laboratory of Applied Mechanics, Champaign—Urbana, Ill.*

Gerry Austin Morgan, Goffstown. Draftsman with Cox Multi-Mailer Company. *93 Blackstone St., Woonsocket, R. I.*

Harry Putnam Richardson, Milford. With Southern Pacific R. R. *560 10th St., Oakland, Cal.*

Fred Dexter Sanborn, Ashland. Paper Box Manufacturer. Publisher of Weekly Newspaper and Mgr. Job Printing Plant. *Ashland.*

Fred Webster Smith, Franklin Falls. Representative of Geo. D. Mayo Machine Co. *Sixth and Arch Sts., Laconia.*

Benjamin D. Tolles, Somersworth. With Great Falls Manufacturing Company, Department of Carding. *Berwick, Maine.*

18—*1

1899.

Henry Clark Baker, South Yarmouth, Mass. Electrical Engineer, Care Crocker-Wheeler. *Ampere, N. J.*

Harry Everett Barnard, Nashua. State Chemist, State House, Indianapolis, Ind.

Harrison Edward Clement, Nashua. Member American Institute Mining Engineers, Mining Engineer. Member of firm Clement & Strange, Engineers and Contractors. *312 Dooley Block, Salt Lake City, Utah.*

Irving Atwell Colby, Exeter. Designer with Shelby Steel Tube Co. *Box 66, Ellwood City, Penn.*

Willis Daniel Farley Hayden, Hollis. Farm Manager. *Stark Ave., Dover.*

Frederick Libbey Horton, Dover. Engineering Department General Electric Company. *35 Lovers' Leap Avenue, Lynn, Mass.*

William Elmer Hunt, Nashua. Captain Twenty-Second United States Infantry. Professor of Military Science and Tactics, New Hampshire College. *Durham.*

Lewis Hobart Kenney, M. E., Pownal, Me. Draftsman-in-charge, Dept. of Steam Engineering, U. S. Navy Yard. *U. S. Navy Yard, Phila. Penn.*

Grace Agnes Mark (Mrs. Herbert F. Moore), Gilsum. *710 West Hill St., Champaign, Ill.*

Arthur Zebulon Norcross, Rindge. Farmer. *Pomfret, Conn.*

Harry Nelson Putney, Franklin. Machinist B. & M. R. R. Shops. *Concord.*

Etta Lillian Simpson, Durham. Principal Dartmouth High School. *Dartmouth, Mass.*

12—

1900.

Herbert Prescott Andrews, Hollis. Engineer, Century Electric Co. *404 North 4th St., St. Louis, Mo.*

David Burns Bartlett, J. B. and J. M., Boston University Law School, 1907; Manchester. Lawyer. *53 State St., Boston, Mass.*

Frances Burnham (Mrs. Robert McA. Keown), Durham. *206 No. Brooks St., Madison, Wis.*

Blanche Mary Foye, Durham. Teacher, French and German. *Concord, Mass.*

Charles Elliott Page Mathes. Manager Contract Dept,. L. R. Ry. & Elect. Co. *Little Rock, Ark.*

Edward Emil Nelson, Nashua. Member of American Institute of Mining Engineers. With American Smelting and Refining Co. *62 E St., Salt Lake City, Utah.*

Alvena Pettee (Mrs. Edward E. Nelson), Bachelor's Diploma in Domestic Science, Teachers' College, Columbia University, 1903; Durham. *62 E St., Salt Lake City, Utah.*

Marie Livingstone Robertson (Mrs. Benjamin M. Duggar), Buffalo, N. Y. *Ithaca, N. Y.*

Walter Noah Shipley, Nashua. Steam Turbine Department, Gen-

eral Electric Company, *138 Lakeview Ave., Lynn, Mass.*

Charles Edwin Stillings, Somersworth. Power House Operator. With Interborough Rapid Transit Co., New York City. *74th St. and East River, New York, N. Y.*

John Ernest Wilson, Hollis. Electrical Contractor. *217 1-2 West 1st St., Los Angeles Cal.*

Robert Morrill Wright, Hill. Dealer in Flour, Feed, Grain and Hay. *Hill.*

12—

1901.

Henry Harold Calderwood, Nashua. Turbine Assembly Department with General Electric Co. *428 Central St., Saugus, Mass.*

Charles Henry Courser, Warner. Chief Engineer, Wheelwright Paper Mills, Hardwick, Leominster and Fitchburg. *Leominster, Mass.*

Alice Emerson Dorr, (Mrs. Lewis Cilley); Dover. *11 Summer St., Dover.*

Harry Willis Evans, Portsmouth. Testing Engineer, Commonwealth-Edison Company. *550 La Salle Ave., Chicago, Ill.*

Harry Gilbert Farwell, Keene. Engineering Department, General Electric Company. *403 Summer St., Lynn, Mass.*

Ella Gertrude Gowen, Dover. Giving Lessons in Cookery. *15 Lexington St., Dover.*

Charles Almon Hunt, Nashua. First Lieutenant, Seventh U. S. Infantry. *Fort Brady, Sault Ste. Marie, Mich.*

Edwin Price Jewett, Lakeport. In charge of Prescription Department Walker Gordon Laboratory Co. *2112 Michigan Ave., Chicago, Ill.*

Robert McArdle Keown, Pomona, Fla. Asst. Professor in Machine Design, University of Wisconsin. *206 No. Brooks St., Madison, Wis.*

Elmer Eugene Lyon, Wentworth. Teacher History and Civil Government, Rugby Academy. *4803 St. Charles Ave., New Orleans, La.*

George J. Penneo, Hampstead. Farmer. *Hampstead.*

Harold Morrison Runlett, Durham. Wholesale Shoe Business. With Clark Hutchinson Co., 121 Duane St., New York, N. Y.

Edson Albert Straw. With the A. K. Co., Box Dept. *Ashland.*

13—

1902.

Mary Doe, (Mrs. Charles H. Ayres), Rollinsford.
21 W. 31st St., New York, N. Y.

Edwin W. Gilmartin, Nashua. *9 Middle St., Nashua.*

John C. Kendall, Peterboro. State Dairy Commissioner.
Manhattan, Kans.

Harry M. Lee, Moultonborough. Foreman Buena Vista Farm.
Windsor, Vt.

Abiel A. Livermore, Wilton, Rose Grower.
290 Salem St., Wakefield, Mass.

George E. Merrill, B. Ag., Cornell University, 1903; Newburyport, Mass. Special Field Agent, Bureau of Entomology, U. S. Dept. of Agriculture. *Washington, D. C.*

Charles A. Payne, Portsmouth. Technical Asst. Heating—Engineering Dept., G. E. Co. *320 McClellan St., Schenectady, N. Y.*

Eugene P. Runlett, Durham. With Williams & Clark Shoe Manufacturers, Lynn, Mass.

Arthur L. Sullivan, Suncook. Chemist, Bureau of Chemistry U. S. Dept. of Agriculture.
1461 Chapin Street, N. W., Washington, D. C.

9—

1903.

Harry David Batchelder, West Upton, Mass. Chief Chemist, Carnegie Steel Co., Sharon Coke Works, South Sharon, Penn.
Box 491, Sharon, Penn.

Edgar Forest Bickford, Rochester. Asst. Electrical Engineer, B. & N. St. Ry. Co. & O. C. St. Ry. Co.
84 State St., Boston, Mass.

Frank Ray Brown, Durham. Instructor in Shopwork, New Hampshire College. *Durham.*

Everett William Burbeck, Haverhill. Mining & Civil Engineer with Oliver Iron Mining Co. *Box 370, Eveleth, Minn.*

Everett Garfield Davis, Newmarket. Provision Dealer.
Kingston.

Albert Noah Otis, Durham. With Ford, Bacon & Davis, Consulting Engineers and Contractors. *24 Broad St., New York, N. Y.* *806 Gay St., Knoxville, Tenn.*

Ralph Harvey Rollins, East Concord. Engineer U. S. Reclamation Service. *Yuma, Ariz.*

Morris Archer Stewart, Dover. Chemist. *121 Belknap St., Dover.*

David Albert Watson, Durham. Farming.
R. F. D. No. 1, Durham.

Melvin Johnson White, M. A., Univ. of Wisconsin, 1907; Farmington. Instructor of American History and Civics in High School. *208 No. Brooks St., Madison, Wis.*

10—

1904.

Leander Ashton, Pittsfield. Carnation Grower. *High Street, Framingham Center, Mass.*

Walter Allen Barker, Pittsfield. Civil Engineer with Stone & Webster Engineering Corporation. *15 Exchange St., Boston, Mass.*

Edgar Charles Bickford, Durham. Electrical Assistant at B. E. Ry. E. E. Office. *552 Harrison Ave., Boston, Mass.*

Percy Anderson Campbell, Litchfield. Professor of Animal Industry, University of Maine. *Orono, Maine.*

Carroll Winfred Farr, North Weare. Dairy Farmer and Breeder of Ayrshire Cattle. *North Weare.*

Joseph Ezra Goodrich, New Durham. Master of Ridge School. *Chapin Cottage, Washington, Conn.*

George Herbert Hill, La Crosse, Wis. Draughtsman at Office of Supt. of Shops, Chicago, Burlington & Quincy R. R. *C. B. & Q., Aurora, Ill.*

Thomas Jefferson Laton, Nashua. Instructor in Mechanical Drawing, New Hampshire College. *Box 155, Durham.*

Raymond Louis Lunt, Dover. Telephone Engineer, Western Electric Co. *463 West St., New York, N. Y.*

Arthur Ronello Merrill, North Bridgton, Me. Dairy Farmer. *Norfolk St., Holliston, Mass.*

Samuel Ambrose Richardson, Charlestown. Foreman for G. M. Gest, Conduit Contractor. *277 Broadway, New York, N. Y.*

11—

1905.

John Henry Chesley, Rockingham. Turbine Testing Department, General Electric Company. *77 Mall St., West Lynn, Mass.*

Cleon Orestes Dodge, Sunapee. Chemist, Bureau of Chemistry. *Bureau of Chemistry, Washington, D. C.*

Silas Bryden Hayden, South Natick, Mass. Engineer. *Box 958 Gary, Ind.*

Harry Linwood Hayes, Exeter. Testing Dept., General Electric Company. *Schenectady, N Y.*

Warren Chauncey Hayes, Durham. Graduate Student, New Hampshire College. *Durham.*

Fred Harvey Heath, Warner. Student in Graduate School of Yale University and Asst. in Qualitative Analysis in Kent Laboratory.
P. O. Box 712, Yale Station, New Haven, Conn.

*Harold Nims Knight, Marlborough.

Joseph Wesley Moreton, Medford, Mass. Electrical Engineer, Niagara, Lockport and Ontario Power Co.
Y. M. C. A. Bldg., Buffalo, N. Y.

Orlo Dudley Mudgett, Gilmanton. Sales Department, Westinghouse Electric & Manufacturing Company.
716 Board of Trade Bldg., Boston, Mass.

Horace James Pettee, Durham. Structural Draftsman, Illinois Steel Co. *550 La Salle Ave., Chicago, Ill.*

Arthur Mahlon Pike, Dover. Construction Foreman, General Electric Co. *Schenectady, N. Y.*

Fred Silver Putney, M. S., Penn. State College, 1908, Hopkinton. Scholar at Univ. of Missouri, 1908-'09. *Columbia, Mo.*

John Leslie Randall, M. S., Lee. Teacher, State Normal School.
California, Penn.

William Orrin Robinson, M. S., Marlborough. Physical Chemist, Bureau of Soils, Dept. of Agriculture.
Bur. of Soils, Washington, D. C.

*Harry Union Russell, West Derry.

Elmer Seth Savage, Lancaster. Instructor in Animal Husbandry, Cornell University. *606 No. Aurora St., Ithaca, N. Y.*

Castine Caroline Swanson, Cambridge, Mass.
10 Hollis St., Cambridge, Mass.

Frank Alvin Tinkham, Grafton. Farming. *Grafton.*

18—*2

1906.

Samuel Taylor Adams, Pittsfield. *Durham.*

Stuart Kendrick Barnes, Walpole. Chief Chemist, Retort Coke Oven Co. *Cleveland, Ohio.*

Charles S. Batchelder, South Hampton. Market Gardening.
Waban, Newton Centre, Mass.

Willis Cassius Campbell, West Windham.
4651 Drexel Boulevard, Chicago, Ill.

John Dustin Clark, Nashua. Associate Professor of Chemistry, Univ. of New Mexico. *Albuquerque, N. Mex.*

Clarence Elbert Clement, Derry. Dairyman.
Cherry Hill Farm, Beverly, Mass.

Ernest Luther Converse, Amherst. Instructor in Sciences, Virginia Institute. *Bristol, Va.*

Neil Starr Franklin, Bernardston, Mass. With Westinghouse Electric and Manufacturing Co.
1105 South Ave., Wilkinsburg, Penn.

Carl Tilson Fuller, Nashua. Chemical Engineer, General Electric Co. Lamp Works. *Harrison, N. J.*

William Safford Gooch, Exeter. Engineering Department, New England Tel. & Tel. Co. *164 High St., Boston, Mass.*

Ralph Edward Gowen, Stratham. Running Power House for Carbon Coal Co. *Carbon, W. Va.*

Edwin Davis Hardy, Nashua. Testing Steam Turbines.
E. Pittsburg, Penn.

Cyrus Fremont Jenness, Gonic. Market Gardening.
Waban, Newton Centre, Mass.

Allen Montague Johnson, Nashua. *9 Locust St., Nashua.*

Wallace Fuller Purington, South Yarmouth, Mass. Assistant Chemist, New Hampshire State Board of Health, Laboratory of Hygiene, Concord. *Concord.*

Edwin Jay Roberts, Laconia. Graduate Student, Assistant in Kent Chemical Laboratory.
Box 712, Yale Station, New Haven, Conn.

Roy Vance Swain, Barrington, With Autocar Company.
45 Wyoming Ave., Ardmore, Penn.

Charles Leo Tuttle, Exeter. Engineering Department, New England Tel. and Tel. Co. *164 High St., Boston, Mass.*

18—

1907.

Leon Dexter Batchelder, West Upton, Mass. Asst. Florist, Dept. of Horticulture, Cornell University. *Ithaca, N. Y.*

Philip Ray Berry, Alton. *Alton.*

Andrew Broggini, Concord. Turbine Testing Dept., General Electric Company. *77 Mall, West Lynn, Mass.*

Harold Hurst Dickey, Manchester. Dept. Manager John A. Whalley Company. *209 Coleman Bldg., Seattle, Wash.*

Carl Austin Dodge, New Boston. Asst. Chemist, Wellsbach Light Company. *Gloucester City, N. J.*

Harry Edward Ingham, Nashua. Instructor in Shopwork, New Hampshire College. *Box 155, Durham.*

Frank Davis Lane, Manchester. Instructor.
79 Walnut St., Manchester.

Ralph Albion Littlefield, Portsmouth. Dairy Farming.
N. Reading, Mass.

Bernard C. Noyes, Lisbon. Massachusetts State Forest Service.
Room 7, State House, Boston, Mass.

John Glenn Powers, Concord. Instructor in the Abbott School. *Farmington, Maine.*

Frank Wiggin Randall, Portsmouth. *Portsmouth.*

Ellice Storrs Townsend, (Mrs. C. D. Hazen, Jr.), Lebanon. *White River, Vt.*

Lucia Soule Watson, Durham. Teacher in Enfield High School. *Wells St., Enfield.*

Arthur Jason Woodward, Lancaster. Testing Dept. General Electric Company. *303 Lenox Road, Schenectady. N. Y.*

14—

1908.

Waldo Lawrence Adams, Townsend, Mass. *Durham.*

Arthur Hosea Barton, Newport. *Durham.*

Arthur Milliken Batchelder, Suncook. *Suncook.*

Minot Giles Buss, Wilton. Teacher Berlin High School. *Berlin.*

Lawrence Andrew Carlisle, Exeter. *18 Oak St., Exeter.*

James Dennis Cash, Massabesic. Teacher. *Manchester.*

Mary Abbie Chesley, Durham. Teacher. *Thetford, Vt.*

Francis Clough, Contoocook. General Electric Company. *Lynn, Mass.*

Charles Francis Cone, Nashua. *4 Myrtle St., Nashua.*

Merton Maine Cory, Nashua. *12 Park St., Nashua.*

John Timothy Croghan, Concord. *Concord.*

Katharine DeMerritt, Durham. Teacher. *124 W. Broad St., Westerly, R. I.*

Walter Woods Evans, East Kingston. Graduate Student at University of Toronto. *Chemical Dept., University of Toronto.*

Oren Lovell Farwell, Chesham. Chesham.

Harry Fifield French, Plymouth. Asst. Chemist, State Lab. of Hygiene, Concord. *16 South St., Concord.*

Stanley Fiske Hill, Nashua. *Nashua.*

Merritt Chase Huse, Concord. *11 No. Spring St., Concord.*

William R. Kirkpatrick, Nashua. Gypsy Moth Inspector, U. S. Govt. *Box 77, Nashua.*

John Joseph O'Connor, Portsmouth. *3 Porter St., Portsmouth.*

John Caleb Page, Dover. *Sixth St., Dover.*

George Arthur Perley, Goffstown. Graduate Student at Cornell University. *715 State St., Ithaca, N. Y.*

Sarah Elizabeth Pettee, Durham. Student at Teachers' College, Columbia University. *1230 Amsterdam Ave., New York, N. Y.*

James Henry Priest, Manchester. *711 Beech St., Manchester.*

Moses Herman Sanborn, Fremont. *Fremont.*

Dean Fred Smalley, Walpole. Private Business. *Walpole.*

Carl Brown Tarbell, Milton. Surveying. *No. Rochester.*

Ray Emery Wadleigh, Kensington. Illuminating Engineer, Southern Electric Company. *Baltimore, Md.*

George Lyman Waite, Dunbarton. *Concord, Route 2.*

Harold Duncan Walker, Kittery, Me. *Kittery, Me.*

Francis Ward Woodman, W. Derry. Graduate Student and Fellow at University of Missouri. *417 Witt St., Columbia, Mo.*

30—

TWO YEAR COURSE IN AGRICULTURE.

Lyman Charles Stratton, Hollis, 1897. Superintendent Dairy Farm. *St. George, Ga.*

Charles Wesley Martin, Durham, 1898. Clerk and Assistant with Sacramento Gas, Electric & Railway Company. *3219 Magnolia Ave., Oak Park, Sacramento, Cal.*

George Henry Wheeler, Temple, 1898. Farmer. *Temple.*

Fred Joseph Durell, Newmarket, 1900. Farmer. *Newmarket.*

Harry Alvin Elliott, Lyme, 1900. Blacksmith. *Lyme.*

Edward Augustus Hills, Hollis, 1900. Farmer. *Hollis.*

Albert Cate Knowles, Epsom, 1900. Farmer and Seed Agent. With Dunlap & Sons, Nashua. *Epsom.*

†Robert Hale Pearson, Webster, 1900.

Charles Nicklin Blodgett, Hebron, 1901. Manager Breezy Point Farm, Breezy Point. *Warren.*

Harry Douglass Verder, Hollis, 1901. Stock Raiser. *Hollis.*

Rufus Leonard Cushman, North Adams, Mass. 1901. Gardener. *No. Auburn, Mass.*

†George R. Brew, Lowell, Mass., 1902.

Carroll W. Farr, North Weare, 1902. B. S. New Hampshire College, 1904.

George F. Hills, Hollis, 1902. Farmer. *Hollis.*

Walter E. Quimby, Deerfield, 1902. Farm Superintendent. *Center Belmont, Maine.*

Walter P. Tenney, Chester, 1902. Homedale Farm. *Chester.*

†Thornton N. Weeks, Greenland, 1902.

Robert E. Whittier, Deerfield, 1902. Supt. Maplewood Farm, Danvers, Mass.

Edward C. Wilson, Wilton, 1902. Live Stock Commission, Union Stock Yards, care of Wood Bros. *6022 Princeton Ave., Chicago, Ill.*

Harry Garfield Brierley, Dover, 1903. Farmer. *Stratham.*

†George Grover Manning, Boston, Mass., 1903.

James Henry Nixon, East Brentwood, 1903. Superintendent Red Hill Farm. *R. F. D. 1, Centre Harbor.*

Roscoe Franklin Swain, South Hampton, 1903. Dairy Farmer. *Amesbury, Mass.*

Erland Graves Batchelder, Wilton, 1904. Dairy Farmer, Poultryman and Fruit Grower. *Wilton.*

Wesley Pillsbury Flint, Newburyport, Mass., 1904. Field Assistant in Entomology, Office State Entomologist. *Urbana, Ill.*

Henry Marston Shurbert, Northwood Ridge, 1904. Gardener for Mrs. W. E. Barrett. *West Newton, Mass.*

Arthur G. Dunn, Harrisville, 1905. Manager of Mine Brook Farm. *R. F. D., Medfield, Mass.*

Henry N. Gowing, Dublin, 1905. Poultryman and Fruit Grower. *Dublin.*

Alfred Walter Clough, 1906. Farmer. *Greenland.*

Oliver Carter Dimond, West Concord, 1906. Farmer. *R. F. D. No. 12, West Concord.*

Ralph Wayne Forristall, Alstead, 1906. Farmer. *Alstead.*

Stanley Hargreaves, 1906. Assistant, Forest Park, Springfield, Mass.

Robert S. Sawyer, 1906. Farmer. *Walpole.*

David Raymond Batchelder, Wilton, 1907. Dairyman. *Cherry Hill Farm, Beverly, Mass.*

Alfred Elwin Blood, East Sullivan, 1907. Farmer. *East Sullivan.*

Abram Lawrence Dean, Taunton, Mass., 1907. *Madbury.*

Simes Frink, Newington, 1907. Farmer. *Newington.*

William Patrick Hickey, Bow, 1907. Timekeeper, Carnegie Steel Company. *Newark, N. J.*

Frederick Henry Charles Kampe, East Alstead, 1907. Agriculturist. *East Alstead.*

Lee Augustus Parker, Keene, 1907. Gardener. *195 Eastern Ave., Keene.*

Lewis Elwell Sanborn, Ashland, 1907. Dairyman. *380 Plainfield St., Springfield, Mass.*

Ernest Eugene Tucker, Durham, 1907. Head Gardener Private Estate. *Dublin.*

Charles Shannon Wright, Portsmouth, 1907. Student New Hampshire College. *Durham.*

George A. Holmes, Langdon, 1908. *Langdon.*

Guy Leavitt, Sanbornton, 1908. *Sanbornton.*

Harold Thom Littlefield, Salem Depot, 1908. *Salem Depot.*

SUMMARY.

Graduates, Bachelors of Science, 1871-1908	346
Graduates, Two Year Course	46
Agriculturists	44
Business Pursuits	47
Chemists	17
Civil, Mechanical, Electrical and Mining Engineers	56
Draftsmen	6
Graduate Students	7
Lawyers	7
Manufacturers and Mechanics	27
Physicians	14
Teachers	43
Unknown	10
United States Army	2
United States Weather Bureau	6
Dead	20

ALPHABETICAL LIST OF GRADUATES.

Adams, E. E., 1878.
Adams, G. E., 1885.
Adams, F. S., 1895.
Adams, L. A., 1908.
Adams, S. T., 1906.
Adair, R. K., 1877.
Alden, R. S., 1885.
Aldrich, H. C., 1876.
Aldrich, W. H., 1875.
Aldrich, T. E., 1881.
Andrews, H. P., 1900.
Angier, W. E., 1885.
Arnold, E. F., 1883.
Ashton, L., 1904.
Bailey, C. H., 1879.
Bailey, E. A., 1885.
Baker, H. C., 1899.
Ballard, W. P., 1871.
Barker, P. L., 1892.
Barker, W. A., 1904.
Barnard, H. E., 1899.
Barnard, H. L., 1881.
Barnes, S. K., 1906.
Barney, H. W., 1897.
Bartlett, Miss C. A., 1897.
Bartlett, D. B., 1900.
Bartlett, E., 1872.
Bartlett, Miss M. B., 1897.
Barton, A. H., 1908.
Batchelder, D. R. (2 year), 1907.
Batchelder, A. M., 1908.
Batchelder, C. S., 1906.
Batchelder, E. G. (2 year), 1904.
Batchelor, H. D., 1903.
Batchelor, L. D., 1907.
Berry, P. R., 1907.
Bickford, E. C., 1904.
Bickford, E. F., 1903.
Bickford, P. G., 1885.
Bigelow, F. L., 1883.
Birtwhistle, F. S., 1883.
Blodgett, C. N. (2 year), 1901.
Blood, A. E. (2 year), 1907.
*Boardman, G. J., 1881.
Boutwell, H. L., 1882.
Brew, G. R. (2 year), 1902.
Brierley, H. G. (2 year), 1903.
Brigham, E. L., 1876.
Brill, A. W., 1885.
Bristol, E. F., 1881.
Bristol, N. D., 1883.
Britton, F. C., 1895.
Britton, W. E., 1893.
Broggini, A., 1907.
*Brooks, H., 1877.
Brooks, P. C., 1885.
Brown, B. S., 1894.
Brown, F. R., 1903.
Bryant, F. J., 1893.
Buck, W. F., 1897.
Bugbee, D. J., 1882.
Burbeck, E. W., 1903.
Burleigh, A. T., 1881.
*Burleigh, R. F., 1882.
Burnham, Miss F., 1900.
Buss, M. G., 1908.
Butterfield, J. W., 1876.
*Butterfield, R. C., 1898.
Buzzell, Miss H., 1898.
Calderwood, H. H., 1901.
Campbell, P. A., 1904.
Campbell, W. C., 1906.
Carlisle, L. A., 1908.
Carpenter, L. J., 1882.
*Carr, M. B., 1888.
Carson, J. W., 1877.
Cash, J. D., 1908.
Caverno, Miss B. E., 1898.
Chamberlin, A. F., 1876.
Chapin, R. C., 1879.

*Dead

Chesley, J. H., 1905.
Chesley, Miss M. A., 1908.
*Chubert, C. O., 1877.
Clark, J. D., 1906.
Clement, C. E., 1906.
Clement, H. E., 1899.
Clough, A. W. (2 year), 1906.
Clough, F., 1908.
Colby, F. H., 1889.
Colby, I. A., 1899.
Colburn, A. W., 1897.
Cole, E. G., 1891.
Comings, Miss C. L., 1897.
Comings, F. P., 1883.
*Comings, Miss M. E., 1897.
Cone, C. F., 1908.
Conradi, Albert; M. S., 1902.
Converse, E. L., 1906.
Corbett, B. A., 1898.
Cory, M. M., 1908.
Courser, C. H., 1900.
Cragin, L. M., 1879.
Croghan, J. T., 1908.
Cross, A. B., 1876.
*Cummings, E. S., 1884.
Currier. W. S., 1887.
Curtis, F. P., 1875.
Cushman, R. L. (2 year), 1901.
Davis, E. G., 1903.
Davis, F. A., 1886.
Davis, F. C., 1884.
Davis, H. G., 1888.
Dean, A. L. (2 year), 1907.
Dearborn, N.; D. Sci., 1901.
DeMerritt, Miss K., 1908.
Dennett, I. L., 1897.
Dewey, E. P., 1882.
Dimond, O. C., (2 year), 1906.
Dickey, H. H., 1907.
Dodge, C. A., 1907.
Dodge, C. O., 1905.
Doe, Miss M., 1902.
Dorr, Miss A. E., 1901.
Dunn, A. G. (2 year), 1905.
Durell, F. J. (2 year), 1900.
Durgin, A. C., 1898.
*Edwards, C. A., 1877.
Eldredge, F. E., 1873.
Elliott, H. A. (2 year), 1900.
Ely, F. D., 1881.
Emerson, F. J., 1885.
Emerson, F. V., 1875.
Emery, S. E., 1881.
Evans, H. W., 1901.
Evans, W. W., 1908.
Everett, R. M., 1901.
Farr, C. W., 1904; (2 year), 1902.
Farwell, H. G., 1901.
Farwell, O. L., 1908.
*Flint, W. F., 1877.
Flint, W. P. (2 year), 1904.
Everett, R. M., 1891.
Follansbee, F. H., 1883.
Foord, J. A., 1898.
Forristall, E. H., 1897.
Forristall, R. W. (2 year), 1906.
Foster, S. M., 1884.
Foye, Miss B. M., 1900.
Franklin, N. S., 1906.
French, A. C., 1883.
French, H. F., 1908.
Frink, S. (2 year), 1907.
Fuller, C. T., 1906.
Fuller, F. D., 1892.
Fullerton, J. W., 1898.
Gay, J. E., 1883.
Gerrish, E. C., 1888.
Gillis, L. C., 1889.
Gilmartin, E. W., 1902.
Given, A., 1898.
Gooch, W. S., 1906.
Goodrich, J. E., 1904.
Gowen, Miss E. G., 1901.
Gowen, R. E., 1906.

*Dead

Gowing, H. N. (2 year), 1905.
Gunn, F. W., 1894.
Hall, C. C., 1877.
Hancock, E. H., 1898.
Hardy, A. W., 1887.
Hardy, C. W., 1875.
Hardy, E. D., 1906.
Hardy, M. F., 1874.
Hargreaves, S. (2 year), 1906.
Harvey, J. E., 1886.
Hayden, S. B., 1905.
Hayden, W. D. F., 1899.
Hayes, H. L., 1905.
Hayes, L. D., 1897.
Hayes, Miss M. L., 1898.
Hayes, W. C.. 1905.
Hazen, A., 1885.
Hazen, C. H., 1881.
Hazen, W. N., 1888.
Heath, F. H., 1905.
Henry, J. G., 1877.
Hewitt, C. E., 1893.
Hickey, W. P. (2 year), 1907.
Hill, G. H., 1904.
Hill, H. E., 1894.
Hill, S. F., 1908.
Hills, E. A. (2 year), 1900.
Hills, G. F. (2 year), 1902.
Hirakawa, T., 1898.
*Hollister, C. P., 1877.
Holman, G. M., 1877.
Holmes, G. A. (2 year), 1908.
*Holmes, N. C., 1879.
Hood, C. H., 1880.
Horton, F. L., 1899.
Hough, A. B., 1892.
Howe, F. W., 1894.
Hubbard, C. A., 1877.
Hubbard, C. L., 1893.
Hunt, C. A., 1901.
Hunt, J. N., 1897.
Hunt, W. E., 1899.
Huse, M. C., 1908.
*Hutchinson, L. J., 1889.
Ingham, H. E., 1907.
James, O. M., 1893.
Jenkins, E. D., 1897.
Jenness, C. F., 1906.
Jewell, H., 1875.
Jewett, J. Y., 1890.
Jewett, E. P., 1901.
Johnson, A. M., 1906.
Kampe, F. H. C. (2 year), 1907.
Kelley, E. D., 1883.
Kendall, J. C., 1902.
Kenney, L. H.; M. E., 1906.
Keown, R. McA., 1901.
*Kilburn, E., 1878.
Kimball, H. H., 1884.
Kimball, W. W., 1876.
Kirkpatrick, W. R., 1908.
Kittredge, L. H., 1896.
*Knight, H. N., 1905.
Knowles, A. C. (2 year), 1900.
Lane, F. D., 1907.
Laton, T. J., 1904.
*Leavitt, C. O., 1875.
Lee, H. M., 1902.
Littlefield, H. T. (2 year), 1908.
Littlefield, R. A., 1907.
Livermore, A. A., 1902.
Loveland, G. A., 1882.
Lunt, R. L., 1904.
Lyon, E. E., 1901.
*McGregor, J. L., 1875.
Mann, M. B., 1884.
Manning, G. G. (2 year), 1903.
Mark, Miss G. A., 1899.
Marston, F. P., 1881.
Mason, J. W., 1882.
Mason, W., 1897.
Martin, C. W. (2 year), 1898.
Mathes, C. E. P., 1900.
Mathes, H. C., 1898.

*Dead.

Megrath, W. A., 1881.
Merrill, A. R., 1904.
Merrill, G. E., 1902.
Moore, G. M., 1884.
Moore, H. F., 1898.
Moreton, J. W., 1905.
Morgan, A. B., 1883.
Morgan, G. A., 1898.
Mudgett, O. D., 1905.
Mullins, G. M., 1885.
Nelson, E. E., 1900.
Nichols, H. A., 1882.
Nixon, J. H., (2 year), 1903.
Norcross, A. Z., 1899.
Norris, J. L., 1889.
Norris, Z. A., 1884.
Noyes, B. C., 1907.
O'Connor, J. J., 1908.
O'Gara, E. D., 1888.
Otis, A. N., 1903.
Page, J. C., 1908.
Parker, D. D., 1876.
Parker, F. C., 1879.
Parker, L. A., (2 year), 1907.
Payne, C. A., 1902.
Pearson, R. H. (2 year), 1900.
Peck, E., 1875.
Penneo, G. J., 1901.
Perkins, L., 1871.
Perley, G. A., 1908.
Pettee, Miss S., 1908.
Pettee, H. J., 1905.
Pettee, Miss A., 1900.
Pike, A. M., 1905.
Porter, G. E., 1888.
Powers, J. G., 1907.
Preston, J. F., 1890.
Priest, J. H., 1908.
Purrington, W. F., 1906.
Putney, F. S., 1905.
Putney, H. N., 1899.
Quimby, W. E. (2 year), 1902.
Ramsey, I. W., 1875.
Randall, F. W., 1907.
Randall, J. L.; M. S., 1906.
Record, C. E., 1878.
Richardson, H. P., 1898.
Richardson, S. A., 1904.
Roberts, E. J., 1906.
Robertson, Miss M. L., 1900.
Robinson, W. O.; M. S., 1906.
Rollins, R. H., 1903.
Ruevsky, B. S., 1886.
Runlett, E. P., 1902.
Runlett, H. M., 1901.
*Russell, H. U., 1905.
Sanborn, E. Q., 1890.
Sanborn, F. D., 1898.
Sanborn, G. A., 1887.
Sanborn, L. E. (2 year), 1907.
Sanborn, M. H., 1908.
Sanders, C. H., 1871.
Sargent, G. J., 1888.
Savage, E. S., 1905.
Savage, H. N., 1887.
*Sawyer, H. A., 1874.
Sawyer, R. S. (2 year), 1906.
Scott, C. W. E., 1889.
Seward, O. L., 1875.
Shaw, R. H., 1897.
Shipley, W. N., 1900.
Shurbert, H. M. (2 year), 1904.
Simpson, Miss E. L., 1899.
Slack, C. I., 1890.
Smalley, D. F., 1908.
Smith, A. W., 1893.
Smith, F. W., 1898.
Smith, J. F., 1873.
Smith, J. W., 1888.
Stanton, F. T., 1881.
Stewart, M. A., 1903.
Stickney, V. H., 1881.
Stillings, C. E., 1900.
Stone, D. E., 1889.

*Dead

Stone, E. M., 1892.
Stone, E. P., 1891.
Stratton, L. C. (2 year), 1897.
Straw, A. E., 1901.
Sullivan, A. L., 1902.
Swain, R. F. (2 year), 1903.
Swain, R. V., 1906.
Swanson, Miss C. C., 1905.
Tarbell, C. B., 1908.
Tenney, W. P. (2 year), 1902.
Thompson, E. C., 1884.
*Thompson, F. E., 1882.
Thurber, M. F., 1886.
Tinkham, F. A., 1905.
Tolles, B. D., 1898.
Townsend, Miss E. S., 1907.
Trow, C. A., 1895.
Tucker, C. H., 1873.
Tucker, E. E. (2 year), 1907.
Tuttle, C. L., 1906.
Verder, H. D. (2 year), 1901.
Vickery, C. W., 1897.
Wadleigh, R. E., 1908.
Waite, G. L., 1908.
Waldron, B. L., 1887.
Walker, G. E., 1888.
Walker, H. D., 1908.
Wallace, S. A., 1881.
Washburn, F., 1889.
Wason, E. H., 1886.
Watson, D. A., 1903.
Watson, Miss L. S., 1907.
Weeks, T. N. (2 year), 1902.
Wheeler, C. A., 1877.
Wheeler, D. A., 1897.
Wheeler, G. H. (2 year), 1898.
Whitcher, G. H., 1881.
White, F. A., 1872.
White, M. J., 1903.
Whittemore, E., 1877.
Whittemore, E. S., 1897.
Whittier, R. E. (2 year), 1902.
Whittier, W. L., 1883.
Wilkins, G. H., 1879.
Willard, E. M., 1875.
Wilson, E. C. (2 year), 1902.
Wilson, J. E., 1900.
Wood, A. H., 1885.
Wood, G. P., 1886.
Woodman, F. W., 1908.
Woodward, A. J., 1907.
Woodward, C. M., 1883.
Wright, C. S. (2 year), 1907.
Wright, R. M., 1900.

*Dead

SPECIMEN ENTRANCE EXAMINATION PAPERS FOR FOUR YEAR COURSES.

ENGLISH.

The purpose of this examination is to test (1) the candidate's knowledge and appreciation of certain specified works, and (2) his ability to write correctly. As bearing on the latter point, he is advised to go over his paper carefully before the end of the time allowed, correcting any inaccuracies, not neglecting capitals and punctuation.

I. (1) Give and illustrate the rules for the comma.

(2) Discuss the use of quotation marks.

II. Arrange in chronological order and name the authors of the following works: Silas Marner, Macbeth, The Sir Roger de Coverly Papers, The Passing of Arthur, Life of Goldsmith, Ivanhoe and The Ancient Mariner.

III. Write not less than 200 words upon two of the following topics:

The Phantom Ship and its Passengers.
The Moral Degeneration of Macbeth.
Sir Roger de Coverly at the Theatre.
Caesar's Behavior on the Day of his Death.
The Plot of Silas Marner.

IV. Discuss fully and carefully four of the following topics:

The topic sentence and its development.
The respective advantages of the long sentence, the periodic sentence, the balanced sentence.
Unity in the paragraph.
Coherence in the composition.
Emphasis in the sentence.

V. Quote at least ten lines from Milton.

AMERICAN HISTORY.

1. Give an account of the principal discoveries, explorations and settlements, made previous to 1607, within the present mainland limits of the United States, by (a) The Northmen, (b-c) The Spanish, (d) The French, (e) The English.

2. Give an account of the American share in the following:—(a) King William's War, (b) Queen Anne's War, (c) King George's War, (d-e) The French and Indian War.

3. Give a brief account of (a) the Stamp Act, (b) the boundaries of the United States according to the Treaty of 1783, (c-d) the nature and history of the Articles of Confederation,

(e) Financial condition of the United States under the Articles of Confederation.

4. Explain the following questions which have been connected with issues since 1865:—(a-b) The conflict over reconstruction, (c) The race problem, (d) The silver coinage struggle, (e) The Venezuelan affair, 1895.

5. Select two subjects from the following and write at least fifty words upon each:—(a) Early education in America; (b) The virtues and limitations of Quakers and Puritans; (c) Patriotism and lack of patriotism during the Revolution; (d) Clay's character and services; (e) The Know-Nothing Party.

6. Give the substance of the last three amendments to the Constitution.

ANCIENT HISTORY.

1. Islands about Greece:—(a) Three important islands or groups in the Aegean; (b) The important island near the eastern coast; (c) Some important island near the western coast; (d-e) The historically important island midway between Greece and Egypt. The important traditions and early history of that island.

2. (a) History and influence of the Delphian oracle. (b) Three classes of people in Sparta. (c-d) Government of Sparta. (e) Myth of Lycurgus.

3. The Persian Invasion:—(a) Brief account of principal expedition sent by Darius; (b-c) Brief accounts of the four important battles resulting from the invasion of Xerxes; (d-c) Outline of collateral reading on the Persian Invasion.

4. Outlines of life and public services:—(a) Pericles; (b) Alcibiades; (c) Socrates; (d) Xenophon; (e) Epaminondas.

5. (a) The causes in Rome leading to the establishment of the tribunate; (b-c) The history and character of the laws of the twelve tables. (d) the war with the Greeks (Pyrrhus). (e) Roman road making.

6. (a-c) Brief outlines of the three wars between Rome and Carthage. (d) The Roman provincial system. (e) Brief accounts of Marius and Sulla.

7. Some account of five books used for collateral reading in Ancient History.

ENGLISH HISTORY.

1. (a-c) Outline map showing the situation of England, the form of the coast, five important rivers, and five important places.

(d) The early Germans: home, customs, institutions.

(e) The English conquest; purpose and manner of coming of the English; principal events.

2. The Hundred Years' War.

(a) Accession of Edward III: character; causes for trouble between England and France; preparations for war.

(b-c) Course of war to 1377: important events; Treaty of Bretigny; causes for English success; renewal of war; state of affairs at close of reign.

(d-e) Renewal of war by Henry V: causes; condition of France; Agincourt; Treaty of Troyes; Joan of Arc; close of the war.

3. England under the Tudors, 1485-1558.

(a) The House of Tudor: characteristics; policy.

(b) The establishment of despotism: measures of Henry VII; condition of the country; position of Parliament; reasons for acceptance of Tudor despotism.

(c) The new learning in England: character of the English movement; leaders; connection with Reformation.

(d) The Reformation under Henry VIII.

(e) The Catholic Reaction under Mary.

4. Wars of Empire, 1689-1815.

(a) Battle of the Boyne. (b) King William's War. (c) Queen Anne's War. (d) King George's War. (e) Strife for the Ohio Valley.

5. War of the French Revolution. (a) The French Revolution. (b-c) War to Peace of Amiens. (d-e) Trafalgar. Waterloo.

MEDIAEVAL AND MODERN HISTORY.

1. Give an outline of the history of Kingdom of the Ostrogoths.

2. Explain the meaning of each of the following words: Janizaries, reliefs, escheats, aids, villeins.

3. What were the characteristics which distinguished the early Teutons.

4 Give an account of the Third Crusade.

5. In one hundred words give the history of Spain from A. D. 700 to A. D. 1500.

6. Give the history of the Russo-Turkish War of 1877-78.

7-8. Write a sketch of each of the following:—Wallenstein, Richelieu, Colbert, Garibaldi.

9. Locate each of the following and describe some historical event connected with the place:—Narva, Versailles, Trafalgar, Sadowa.

10. Draw a map showing the political divisions in the south-east of Europe.

ENTRANCE ALGEBRA.

1 State the general laws for exponents in multiplication and division.

2. Perform the indicated operations and simplify

$$(a+b+c+d)^2 - (a-b-c-d)^2$$

3. Divide

$8x^{m+4} - 18x^{m+3} - 13x^{m+2} + 9x^{m+1} + 2x^m$ by $4x^m + x^{m-1} - 2x^{m-2}$

4. A father is four times as old as his son, but in 24 years the father will be only twice as old as the son. What is the present age of each.

5. Write the factors of

$14\,a^4b + 21\,a^3b^2 - 35\,a^2b^3 - 42\,ab^4$

$15\,c^2 + 22\,c\,x + 8x^2$

$x^5 - y^5$

6. (a) Change to an equivalent fraction having the lowest common denominator $\frac{1}{x+1} + \frac{1}{(x+1)^2} + \frac{1}{(x+}$

(b) Simplify $\frac{m-5x}{m+5x} + \frac{10\,m\,x}{m^2 - 25\,x^2}$

7. Solve for x $\frac{1}{x+1} + \frac{1}{x+2} = \frac{1}{x+3}$

8. Solve for x $\left\{ 3\,x^2 - 8\,x - 16 = 0 \right.$

$\left\{ \frac{a+x}{a-x} = \frac{x-2a}{x+2a} \right.$

9. Expand by the binomial theorem $(2\,x + 4\,b)^4$

10. (a) Simplify $\frac{c}{x}\sqrt{\frac{x^4}{c^3}}$, $\frac{2}{m^2}\sqrt[3]{\frac{54\,m^4}{x}}$

(b) Multiply $\sqrt{-5\,x}$; $\sqrt[3]{-8\,a\,x^3}$; $\sqrt[4]{81\,a\,b\,x^7}$

(c) Multiply $-\sqrt{2c}$; $-3\sqrt{-2a}$; $+2\sqrt{-3b}$; $+a\sqrt{3c}$; $-2\sqrt{bc}$

PLANE GEOMETRY.

1. Prove that if two oblique lines drawn from a point in a perpendicular cut off equal distances from the foot of the perpendicular, they are equal.

2. Prove that if two parallel lines are cut by a third line the alternate interior angles are equal.

3. The exterior angle at base of an isosceles triangle equals 125 degrees, what are the angles of the triangle?

4. Prove that the three bisectors of the angles of a triangle meet at a point.

5. Prove that the diagonal of a parallelogram divides the

figure into two equal triangles.

6. Prove that the sum of the interior angles of any polygon is equal to two right angles, taken as many times less two as the figure has sides.

7. In equal circles two angles at the centre have the same ratio as their intercepted arcs when the arcs are incommensurable.

8. The arc intercepted by a tangent to a circle and a diameter is 75 degrees, what is the angle between the tangent and the produced diameter?

9. Construct a mean proportional to two given lines.

10. Prove if a straight line divides two sides of a triangle proportionally, it is parallel to the third side.

SOLID GEOMETRY.

1. If a line is perpendicular to each of two lines at their point of intersection, it is perpendicular to the plane of the two lines.

2. If a line is perpendicular to a plane, any plane passing through the line is perpendicular to the plane.

3. The sum of the face angles of a convex polyedral angle is less than four right angles.

4. A plane passed through the diagonally opposite edges of a parallelopiped divides it into two equivalent triangular prisms.

5. A triangular prism may be divided into three equivalent triangular pyramids.

6. The lateral surface of the frustum of a regular pyramid is equal to one-half of the product of the slant height by the sum of the perimeters of the bases.

7. The surface of a sphere is equal to the area of four great circles.

8. The measure of a spherical angle is the arc of a great circle described from its vertex as a pole, included between its sides produced if necessary.

9. The area of a spherical triangle is equal to the product of the spherical excess by a tri-rectangular triangle.

10. The angles of a spherical triangle are the supplements of the sides opposite in the polar triangle.

PLANE TRIGONOMETRY.

1. Define cosine, tangent, secant, anti-tangent, radian.
2. Change 3/5 π to degrees ; 38° to radians.
3. Determine sine,. cosine and tangent of 30°; of 45°.
4. Prove $\sin 2x = 2 \sin x \cos x$.
5. Prove $\sin 2x = \frac{2 \tan x}{1 + \tan^2 x}$
6. The sign of an angle is 2/7. Find remaining functions of same angle.
7. In a right angled triangle one angle is 25°. The hypotenuse is 340. Write formula for side opposite the given angle.
8. In an oblique angled triangle, given the three sides ; write formulas for area and one angle.
9. $\sin 2x - \tan x = 0$. Solve for x.

PHYSICS.

1. Tell what you can of the standards of length, mass and time. What is meant by fundamental units? Distinguish between the gram as a unit of mass, and as a unit of force. Define force and the components of a force. How do you account for the variation in the gravitational units of force as we go from one locality to another?

State and illustrate Newton's laws of motion. State the laws of hydrostatics. State Archimedes' principle. Explain the construction of a simple barometer, and outline carefully the principles upon which its theory is based. Explain why high mountain climbing often causes pain and bleeding in the ears and nose. State the Kinetic Theory of Gases. State the simple machines. Explain the siphon.

2. What is the distinction between heat and temperature? State the effects of heat. Illustrate each. Explain what is meant by saturated and unsaturated vapors, and give their laws.

What is meant by "Absolute Zero?" How do you account for the protection of fish life in winter? What provision is made in steel bridges for the changes due to temperature variations? Distinguish heat of fusion and heat of vaporization. State the principles upon which the ventilation of houses depends.

3. Account for the difference in the intensity of shadows formed by opaque bodies. What is meant by diffusion of light? by reflection? by refraction? the critical angle? a continuous spectrum? Draw sketches to show the formation of images produced by concave mirrors and lenses. Explain the simple microscope. Account for the formation of the rainbow.

4. State the sources of sound, and the characteristics of media by which it is transmitted. Distinguish longitudinal and transverse wave motion. State the characteristics of musical sounds. Define each. Define an echo, resonance, a tone, a harmonic, and sympathetic vibrations. Outline the use of the lips, tongue and teeth in the production of the vowels and consonants.

5. Devise an experiment to show that a piece of iron attracts a magnet just as truly as the magnet attracts the iron. What is meant by a magnetic line of force? a field of force? by the declination of a compass needle? Devise an experiment to show conclusively the existence, simultaneously, of two unlike kinds of electrification when it is produced by friction. Explain the electrophorous. State the effects of an electric current. Describe a simple voltaic cell and tell why it may rapidly run down. State a rule for determining the polarity of a magnet made by placing around it a coil of wire carrying a current.

CHEMISTRY.

1. Define Synthesis, Efflorescence, a base, polymerism, reduction.

2. Give the occurrence in nature and properties of nitrogen and enumerate some of its commercial compounds.

3. If the valence of an element x is 1 write the simplest formula for its carbonate, nitrate, borate and sulphite.

4. Complete the following reactions :

$Fe + HCL =$	$CaCO_3 + HCL =$
$Cu + H_2\,SO_4 =$	$P + O =$
$Cu + HNO_3 =$	$Ag_2SO_4 + NaCl =$
$Ca(OH)_2 + HNO_3 =$	$Na_2SO_4 + BaCl_2 =$
$H_2SO_4 + KOH =$	$AsCl_3 + H_2S =$

5. If one liter of Hydrogen is mixed with 1500 c.c. of Oxygen and the mixture exploded what gas and how much remains unacted upon?

6. How many grains of Ammonium Hydroxide is needed to neutralize 294 grains of sulphuric acid?

7. Give the commercial source, method of preparation and uses of NH_3.

8. Briefly describe two methods of determining molecular weights.

9. Give the occurrence and properties of zinc and describe the method of preparing the metal from its sulphide.

10. State the Law of Mass Action ; the Law of Dulong & Petit ; the Law of Definite Proportions ; the Periodic Law.

Atomic weight of nitrogen = 19.
" " " sulphur = 32.

ZOOLOGY.

1. Define a Protozoan and name two animals which belong to this class.

2. Give the internal structure of an earthworm. How does the earthworm differ from the Coelenterales and Arthropods?

3. Define and describe an insect. How does an insect breathe, and where are its organs of smell and excretion?

4. What is meant by Evolution? How is one species supposed to give rise to another?

5. Define hermaphrodite, hybrid, parasite, mimicry, Aves.

6. Name one animal from each of the following orders,—Mollusca, Arthropoda, Mammalia, Echinodermata and Pisces.

ELEMENTARY BOTANY.

1. Define calyx, petal, stamen, ovary, spike, tendril.

2. What is meant of self-pollination? Cross-pollination? Give an example of each. Name three agencies of cross-pollination.

3. Describe an exogenous stem as seen in cross-section. How does it differ from an endogenous stem?

4. Define tuber, bulb, stolon, bract, internode, petiole. Give an example of each.

5. Define respiration. Define photosynthesis. Compare the two as to necessary conditions, products and value to plant.

6. What are the following and what part does each play in the life of the plant: transpiration, stoma, epidermis, chlorophyll, protoplasm?

7. Give the meaning of the following: plumule, cotyledon, radicle, testa, legume.

8. Describe the form, structure and reproduction of a particular cryptogamous or flowerless plant.

GEOLOGY.

1. Describe the destructive and constructive work of a glacier. What characters of a land surface indicate the action of glaciers during some past age?

2. How are mountains formed? Diagram.

3. Define—continental shelf, anticline, talus, stratum, delta.

4. How is coal formed? What different kinds are there and how are they formed?

5. How is soil formed? Name all the agencies which aid in soil formation.

6. For what was the Triassic period noted? Describe some of the animals and plants then living.

7. How are coral reefs formed? What is an atoll?
8. Define a fossil. Name several of the more common ones.

FRENCH.

1. Where have you studied French? How long? What books have you read?
2. Synopsis simple and compound tenses:
   (1) Third person singular of aller.
   (3) Second person plural of faire.
3. Conjugate:—
   (1) Present of recevoir.
   (2) Future of venir.
   (3) Conditional of vouloir.
4. Principal parts of italicized verbs in 6, 7 and 8.
5. Translate:—
   (1) Should I study well, the master would be glad.
   (2) Durham, September 3, 1907. (Write out date).
   (3) I have not received any money.
   (4) When he comes, he will tell me what he has done.
   (5) You must remain at home today.
   (6) Although he is poor, he is happy.
   (7) Have you finished your lessons? I have finished them.
   (8) How long have you been here?
   (9) I have been here for three days.
   (10) Give me some black coffee, if you please.
6. Translate:—

Un célèbre médecin avait soigné un petit enfant pendant une maladie dangereuse. La mère reconnaissante arrive chez le sauveur de sons fils. "Docteur, *dit*-elle, il y a des services qui ne se payent pas. Je ne *savais* comment reconnaître vos soins. J'ai pensé que vous *voudriez* bien accepter ce porte-monnaie que j'ai brodé de ma main.—Madame, répliqua un peu rudement le docteur, la médecine n'est pas une affaire de sentiment et nos soins veulent être rémunérés en argent. Les petits cadeaux e*ntretiennent* l'amitié mais ils n'entretiennent pas nos maisons. —Mais docteur, dit la dame surprise et blessée, parlez, fixez un chiffre.—Madame, c'est deux mille francs." La dame ouvre le porte-monnaie, en tire cinq billets de banque de mille francs, en donne deux au médecin, remet les trois autres dans le porte-monnaie, salue froidement et se retire.

7. Translate:—

Enfin, ayant *attendu* jusqu'à près de neuf heures, l'ennemi arrivant à pas accélérés, et les ponts ne *pouvant* plus servir

qu'aux Russes si on différait davantage, il se décida, le coeur navré, et détournant les veux de cette scène affreuse, à *faire mettre* le feu. Sur-le-champ des torrents de fumée et de flammes enveloppèrent les deux ponts, et les malheureux qui étailent dessus se précipitèrent pour n'être par entraînés dans leur chute. Du sein de la foule qui n'avait point encore passé, un cri de désespoir s'éleva tout à coup: des pleurs, des gestes convulsifs s'apercevaient sur l'autre rive. Des blessés, de pauvres femmes tendaient les bras vers leurs compatriotes qui s'en allaient, forcés malgré eux de les abandonner.

8. Translate:—

Mais leur douleur bruyante produisait moins d'impression que le désespoir meut d'un personnage qui attirait tous les regards. C'était le malheureux père, qui allant d'un cadavre à l'autre, soulevait leurs têtes souillées de terre, baissait leurs lèvres violettes, *soutenait* leurs membres déjà roidis, comme pour leur éviter les cahots de la route. Parfois on le voyait *ouvrir* la bouche pour parler, mais il n'en sortait pas un cri, pas une parole. Toujours les yeux fixés sur les cadavres, il se heurtait contre les pierres, contre les arbres, contre tous les obstacles qu'il recontrait.

ELEMENTARY GERMAN.

I. Translate.

Frau Biesendahl. Herr Oberlehrer, Sie wissen, dass wir auf eine sehr gute Erziehung halten und dass wir jede Roheit von *unseren Kindern* fernzuhalten suchen. Mein Mann ist Beamter und ich bin die Tochter eines Zollassistenten, da brauch' ich wohl nicht erst zu sagen, dass die Kinder bei uns im Hause niches Schlechtes hören. Herr Flemming erlaubt sich aber Ausdrücke gegen die Kinder, die einfach empörend sind.

II. Translate.

Sie *sprachen* nichts mehr; sie gingen stumm neben einander zum See hinab. Die Luft war schwül, im Westen stieg schwarzes Gewölk auf. "Es wird gewittern," sagte Elisabeth, indem sie ihren Schritt *beeilte*', Reinhardt nickte, und beide gingen rasch am Ufer entlang bis sie ihren Kahn *erreicht* hatten.

Während der Uberfahrt *liess* Elisabeth ihre Hand auf dem Rande des Kahnes ruhen. Er blickte beim Rudern zu ihr hinüber, sie aber sah an ihm vorbei in die Ferne. So glitt sein Blick herunter und *blieb* auf ihrer Hand; und die blasse Hand *verriet* ihm, was ihr Antlitz ihm *verschwiegen* hatte.

III. Translate.

"Thue das nicht!" sagte die Nachtigall. "Der hat ja Gutes

gethan, so lange er konnte! Behalte ihn nur! Ich aber kann im Schlosse nicht wohnen, lass mich daher kommen, wenn ich selbst Lust habe, da will ich des Abends auf diesem Zweige sitzen und dir etwas vorsingen, damit du froh werden kannst! Ich komme weit herum, zu Armen und Reichen, zu Glücklichen und Unglücklichen und werde dir von vielem singen können, was in deinem Reiche *passiert* und dir *verborgen bleibt*. Aber eins musst du mir versprechen."—"Alles!" sagte der Kaiser und stand da in seiner kaiserlichen Tracht, die er selbst *angelegt* hatte, und drückte den goldenen Säbel an sein Herz.

IV. Translate.

Als einst der Doktor ein neues Prachtwerk mitgebracht hatte und mit Freude wahrnahm, wie Marie mit einer gewissen Ostentation das Gespräch mit *dem Grafen* abbrach, um sich an einem Seitentisch von ihm über die abgebildeten Antiken belehren zu lassen, bemerkte der edle Magyar *der Kanzleirätin*, er für seinen Teil hege nicht das mindeste Interesse für den alten Plunder und überlasse dergleichen Sachen den Herren Gelehrten, worauf die Kanzleirätin erwiderte, sie finde das sehr begreiflich; ein Kavalier wie Graf Csanady habe eben eine andere Sphäre als die Bourgeoisie.

V. Prin. parts italicized verbs in II and III.

VI. Translate:

1. Yesterday the day was very beautiful.
2. I took a book and went into the garden to study.
3. The fisherman's dog came out of the hut.
4. I gave him bread: it pleased him.
5. Then he fetched the fisherman from the house and we went to the river to fish.
6. These old soldiers will sleep, but the young king will not see them.
7. The old woman has become very angry.
8. I put the clock on the table at half past eight.
9. If he were here he would go to the theatre.
10. He speaks as if he had much money.

VII. Decline italicized words in I and IV.

VIII. Give synopsis 3rd sing. simple and compound tenses of gehen.

Decline pres. dürfen: wollen: lehren: geben: versprechen.

LATIN ELEMENTARY.

I. Translate into idiomatic English:—

Flumen est Arar, quod per fines Aeduorum et Sequanorum

in Rhodanum influit, incredibili lenitate, ita ut oculis, in utram partem fluat, iudicari non possit. Id Helvetii ratibus ac lintribus iunctis transibant. Ubi per exploratores Caesar certior factus est, tres iam partes copiarum Helvetios id flumen traduxisse, quartam fere partem citra flumen Ararim reliquam esse, de tertia vigilia cum legionibus tribus e castris profectus ad eam partem pervenit, quae nondum flumen transierat. Eos impeditos et inopinantes aggressus magnam partem eorum concidit; reliqui sese fugae mandarunt atque in proximas silvas abdiderunt. (Caesar. Gallic War: Book I.)

II.

Decline fines (line 1) certior (line 5) flumen (line 6)

Syntax of lenitate (line 2) oculis (line 2) legionibus (line 7)

Explain mode of possit (line 3) traduxisse (line 6)

Compare proximas (line 11)

III. Translate into idiomatic English:—

Qua consuetudine cognita Caesar, ne graviori bello occurreret, maturius, quam consuerat, ad exercitum proficiscitur. Eo cum venisset, ea, quae fore suspicatus erat, facta cognovit: Missas legationes ab nonnullis civitatibus ad Germanos invitatosque eos, uti ab Rheno discederent, omniaque, quae postulassent, ab se fore parata. Qua spe adducti Germani latius vagabantur et in fines Eburonum et Condrusorum, qui sunt Treverorum clientes, pervenerant. Principibus Galliae evocatis Caesar ea, quae cognoverat, dissimulanda sibi existimavit eorumque animis permulsis et confirmatis equitatuque imperato bellum cum Germanis gerere constituit.

IV. Syntax of Rheno (line 5) sibi (line 9)

Inflect proficiscitur (line 2) and postulassent (line 5)

Prin. parts of consuerat, (line 2) facta (line 3) vagabantur (line 7)

Decline equitatu (line 10) spe (line 6)

Derivation of legationes (line 4) civitatibus (line 4)

V. Translate into Latin:—

I. Caesar is about to cross the river in order to attack the enemy.

2. They went from the camp at night.

3. If the Germans should send soldiers to us within two days, we would not proceed against them.

4. Since he knew that the soldiers were ready, he quickly crossed the bridge and advanced into the enemy's territory.

ADVANCED LATIN.

I. Translate into idomatic English:—

Hic quis potest esse, Quirites, tam aversus a vero, tam praeceps, tam mente captus, qui neget haec omnia, quae videmus, praecipueque hanc urbem deorum immortalium nutu ac potestate administrari? Etenim, cum esset ita responsum, caedes, incendia interitum rei publicae, comparari, et ea per cives, quae tum propter magnitudinem scelerum non nullis incredibilia videbantur, ea non modo cogitata a nefariis civibus, verum etiam suscepta esse sensistis. Illud vero nonne ita praesens est, ut nutu Iovis optimi maximi factum esse videatur, ut, cum hodierno die mane per forum meo iussu et coniurati et eorum indices in aedem Concordiae ducerentur, eo ipso tempore signum statueretur? Quo collocato atque ad vos senatumque converso omnia quae erant cogitata contra salutem omnium, illustrata et patefacta vidistis. (Cicero. Catiline. III.)

Give reason for mode of neget (line 2) esset (line 4.)

Explain derivation of magnitudinem (line 6) collocato (line 12.)

Syntax of nullis (line 7) civibus (line 8.)

II. Translate into idomatic English.

Ut primum cessit furor, et rabida ora quierunt:
Incipit Aeneas heros: Non ulla laborum,
O virgo, nova mi facies inopinave surgit:
Omnia praecepi, atque animo mecum ante peregi.
Unum oro; quando hic inferni ianua regis
Dicitur, et tenebrosa palus Acheronte refuso;
Ire ad conspectum chari genitoris, et ora
Contingat; doceas iter, et sacra ostia pandas.
Illum ego per flammas et mille sequentia tela
Eripui his humeris, medioque ex hoste recepi;
Ille meum comitatus iter, maria omnia mecum,
Atque omnes pelagique minas coelique ferebat
Invalidus, vires ultra sortemque senectae.
Quin, ut te supplex peterem, et tua limina adirem,
Idem orans mandata dabat. Natique patrisque,
Alma, precor, miserere: potes namque omnia; nec te
Nequicquam lucis Hecate praefecit Avernis.

Scan the following lines, marking principal caesura, etc. Line 1; line 4; line 8.

Explain the form quierunt (line 1) the mode of doceas (line 8.)

Syntax of natique (line 15) lucis (line 17.)

IV. If any one shall accuse me because I have not arrested so wicked a man rather than let him go from the city, that is not my fault, but the fault of the times. Cataline ought to have been killed long ago, but there are very many who defend him and do not believe what I report. If I had punished him by death, his accomplices would have escaped. What crimes have they not committed these years! Would that you knew their plots! There is no nation whom we fear, but we must now contend with all these desperate men.

Exhibit of the New Hampshire Agricultural-Experiment Station at the Rochester Fair 1908.

NINETEENTH AND TWENTIETH ANNUAL REPORTS

OF THE

NEW HAMPSHIRE Agricultural Experiment Station.

NOVEMBER 1, 1906, TO OCTOBER 31, 1908.

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION.

NOV. 1, 1908.

BOARD OF CONTROL.

Hon. JOHN G. TALLANT, *Chairman,*	**Pembroke**
CHARLES W. STONE, A. M., *Secretary,*	**East Andover**
Hon. WARREN BROWN,	**Hampton Falls**
Hon. N. J. BACHELDER, A. M., M. S.,	**East Andover**
Pres. WILLIAM D. GIBBS, D. Sc., *ex officio,*	**Durham**

THE STATION STAFF.

E. DWIGHT SANDERSON, B. S., B. S. Agr., *Director and Entomologist.*

FRED W. MORSE, M. S., *Vice-Director and Chemist.*

FREDERICK W. TAYLOR, B. Sc. (Agr.) *Agriculturist.*

CHARLES BROOKS, PH. D., *Botanist.*

FRED RASMUSSEN, B. S. A., *Dairyman.*

WILLIAM H. PEW, B. Sc. (Agr.) *Animal Husbandman.*

B. S. PICKETT, M. S., *Horticulturist.*

BERT E. CURRY, M. S., *Associate Chemist.*

JASPER F. EASTMAN, B. S., *Assistant Agriculturist.*

C. F. JACKSON, M. A., *Assistant Entomologist.*

WM. H. WICKS, M. S. Agr., *Assistant Horticulturist.*

I. M. LEWIS, M. A., *Assistant Botanist.*

DAVID LUMSDEN, *Assistant in Floriculture.*

W. C. McNUTT, *Herdsman.*

NELLIE F. WHITEHEAD, *Purchasing Agent.*

MABEL H. MEHAFFEY, *Stenographer.*

LAVINIA BROWN, *Assistant Bookkeeper.*

ESTHER LOUISE ADAMS, B. S., *Librarian.*

TABLE OF CONTENTS.

REPORT OF THE DIRECTOR.

To the President of the New Hampshire College of Agriculture and the Mechanic Arts.

Sir:—I beg to submit the following report of the work of the Experiment Station for the biennial period November 1, 1906, to November 1, 1908, with fiscal report for the years ending June 30, 1907, and June 30, 1908.

Administration.

Changes in Staff. The position of Horticulturist of the Station, caused by the resignation of Prof. Rane was filled by the appointment of his former assistant, Harry F. Hall, in November, 1906. Prof. Hall resigned to go into commercial work in June, 1908, and his place was filled by the appointment of B. S. Pickett, a graduate of the Ontario Agricultural College and recently assistant in Pomology at the University of Illinois. The vacancy in the Department of Dairy Manufactures was filled by the appointment of Fred Rasmussen, assistant in the Dairy department of the Iowa Agricultural College and Experiment Station, as head of the department in September, 1907. E. L. Shaw, Associate Agriculturist, resigned in June, 1907, to take a position in the Bureau of Animal Industry, U. S. Dept. of Agriculture, and W. H. Pew, a recent graduate of the Iowa Agricultural College, was elected to the vacancy. In June, 1908, the Department of Animal Husbandry was separated from the Department of Agriculture and Mr. Pew was given charge of the new department. Mr. J. K. Shaw resigned June, 1907, and Mr. J. C. Wilcox of the Michigan Agricultural College was appointed to the vacancy in October, but resigned in June, 1908, and the vacancy was filled by the appointment of W. H. Wicks, a graduate of the Oregon Agricultural College and who has since been doing graduate work at Cornell University. Dr. T. J. Headlee, associate entomologist, resigned in August, 1907, to accept the position of Professor of Zoology and Entomology at the Kansas Agricultural College and Experiment Station. Mr. C. S. Spooner was appointed to this position but resigned in June, 1908, and the vacancy was filled by the appointment of C. F. Jackson, Assistant in Zoology at the Ohio State University. Mr. Jasper F. Eastman, a graduate of the Massachusetts Agricultural College, was appointed as assistant Agriculturist in September, 1907. Mr. I. M. Lewis, teaching fellow in botany, University of Indiana, was appointed assistant botanist in June, 1908. Since the separation of the

Department of Animal Husbandry from the old Department of Agriculture, the name of the latter has been changed to the Department of Agronomy.

It gives me pleasure to state that the members of the staff have shown a cordial spirit of co-operation and sincere desire not only to make experiments and do research work of fundamental value, but in every way possible to advance the agricultural interests of the state. Few experiment stations of the size and with the resources of this station have a staff with equal ability, and if sufficient resources be placed at their command there is no question but that this station can do much for the agricultural uplift of New Hampshire.

FUNDS.

By the passage of the Adams Act in March, 1906, the Station has had an increase in funds over the $15,000 annually appropriated under the Hatch account, of $7000 for the year 1906-7 and $9,000 for the year 1907-8. The Adams Act specifically states that the funds appropriated under it must be used for "conducting original researches or experiments bearing directly on the agricultural industry of the United States." It has become necessary to sharply differentiate the type of work to be done under the Adams fund from that under the Hatch account. Investigations under the Adams fund must be carried on for a series of years and the projects should be adopted only after careful consideration as to the facilities for their prosecution and their relations to the general agricultural interests of the state; but once commenced these projects should be given liberal financial support, both as regards salaries and equipment and should be continued for an indefinite period until completed. These projects under the Adams fund should be such that in the case of the resignation of members of the staff, the selection of new men would be determined upon their ability to continue these projects, rather than having the projects to be carried on determined by the personality of the staff.

On the other hand the work under the Hatch fund may now well consist of experiments having to do with the methods of culture and growth of crops, the improvement of varieties for local conditions and other similar lines of work which may involve investigations of only one or two seasons and which may well be of a more immediate practical nature, but we cannot under the Hatch fund carry on educational work and its income must be used strictly for experiments and investigations. Practically all the running expenses of the Experiment Station

must necessarily be met from the Hatch fund and with the enlargement of the work in the various departments it is increasingly difficult to care for the necessary expenses without exceeding the appropriation under this fund.

PUBLICATIONS.

The following publications have been issued since Nov. 1, 1906:

Bulletins.

No. 128. The Brown-tail Moth and the Gipsy Moth in New Hampshire in 1906. E. Dwight Sanderson and Dr. L. O. Howard. January, 1907. Pgs. 22, figs. 8. Edition 15,000.

No. 129. Seventeenth and Eighteenth Annual Reports. W. D. Gibbs, et al. January, 1907. Pgs. 48, figs. 3. Edition 11,000. (Pages 319-342, figs. 1-7, Apple Insects, and pages 343-353, figs. 8-10, Shade Tree and Woodland Insects, Plates 1-14 inc., as published in the 28th Report of New Hampshire College, were omitted in Bulletin 129, and the figures in Bulletin 129 were not renumbered.)

No. 130. Inspection of Fertilizers in 1906. Fred W. Morse. February, 1907. Pgs. 8. Edition 11,000.

No. 131. Spraying the Apple Orchard. E. Dwight Sanderson, T. J. Headlee and Charles Brooks. April, 1907. Pgs. 48, figs. 36. Edition 15,000.

No. 132. A Plan for Improving the Quality of Milk and Cream Furnished to New Hampshire Creameries. Ivan Comings Weld. May, 1907. Pgs. 12, figs. 6. Edition 15,000.

No. 133. The Inspection of Feeding Stuffs in 1907. Fred W. Morse. November, 1907. Pgs. 8. Edition 11,000.

No. 134. Fertilizer Analysis. Fred W. Morse and Bert E. Curry. December, 1907. Pgs. 8. Edition 11,000.

No. 135. The Respiration of Apples and its Relation to Their Keeping. Fred W. Morse. February, 1908. Pgs. 8, figs. 1. Edition 15,000.

No. 136. The Gipsy and Brown Tail Moths in New Hampshire. E. Dwight Sanderson. February, 1908. Pgs. 63, figs. 34. Edition 25,000. (Printed by order of the Governor and Council.)

No. 137. Strawberries for New Hampshire. H. F. Hall, May, 1908. Pgs. 32, figs. 8. Edition 15,000.

No. 138. Humus in New Hampshire Soils. Fred W. Morse. June, 1908. Pgs. 16, figs. 3. Edition 15,000.

No. 139. Caterpillars injuring Apple Foliage in Late Summer. E. Dwight Sanderson. July, 1908. Pgs. 24. figs. 13. Edition 15,000.

Circulars.

No. 1. Mixing Chemical Fertilizers on the Farm. Fred W. Morse. April 1, 1908. Pgs. 4. Edition, 1,000.

No. 2. Testing Soils for Fertilizer Needs. F. W. Taylor. April 1, 1908. Pgs. 2. Edition 1,000.

No. 3. The Apple Aphis. E. Dwight Sanderson. August 1, 1908. Pgs. 6, figs. 4. Edition 1,000.

No. 4. Oyster Shell Scale. E. Dwight Sanderson. August, 1908. Pgs. 4, figs. 3. Edition 1,000.

No. 5. The San Jose Scale. E. Dwight Sanderson. August 25, 1908. Pgs. 12, figs. Edition 1,000.

No. 6. A Circular of Information Concerning the New Hampshire Agricultural Experiment Station. September, 1908. Pgs. 16, figs., 10. Edition 5,000.

No. 7. Some Essentials in Farm Butter Making. Fred Rasmussen. Sept. 5, 1908. Pgs. 2. Edition 1,000.

School Bulletins.

No. 1. Agricultural Educations thru Rural Schools. E. Dwight Sanderson. May, 1908. Pgs. 20, figs. 6. Edition 3,000.

No. 2. Soil Studies. F. W. Taylor. May, 1908. Pgs. 24, figs. 13. Edition 3,000.

No. 3. Seeds and Seedlings. Charles Brooks. September, 1908. Pgs. 16, figs. 9. Edition 3,000.

Scientific Contributions.

No. 1. The Influence of Minimum Temperatures in Limiting the Northern Distribution of Insects. E. Dwight Sanderson. Reprint from the "Journal of Economic Entomology," Vol. 1. August, 1908. Pgs. 20, maps 7.

No. 2. The Fruit Spot of Apples. Charles Brooks. Reprint from the Bulletin of the Torrey Botanical Club, Vol. 35, September, 1908. Pgs. 50, plates 7.

Twelve press circulars have also been issued and sent to the agricultural press of this state and New England, which are reprinted in this volume.

A new departure in the publications of the station is the series of circulars, which now number seven, which are designed

to give a brief popular summary of the available information on topics about which the station frequently receives requests for information. These circulars are not sent to the general mailing list but are sent to the press and are used in answering correspondence.

In an effort to advance the interests of agriculture and nature study in the rural schools, the Station has prepared and issued three numbers of the New Hampshire College School Bulletin, which is sent to all the teachers of the state free of charge. This is practically a continuation of the old series of Nature Study Leaflets, but it is hoped that it may have a somewhat wider scope and may become a useful link in connecting this institution with the rural schools of the state, and toward encouraging the teachers of our rural schools to look to us for help and encouragement in the introduction of agricultural and nature study work in the common schools of the state.

Inasmuch as this report covers the 20th year since the organization of the Station, it has seemed fitting that a complete list of its publications and a full index to them should be made. Such an index has been therefore appended to the present volume.

Additions to Equipment.

In the fall of 1907 a sheep barn was erected at a cost of about $1,200 for the work in sheep breeding. An implement barn for the Horticultural Department was also erected for housing the tools of this department. The northeastern room on the first floor of Morrill Hall, formerly an agricultural reading room, is now used as the library of the Experiment Station and has been fitted with steel stacks and suitable furniture, making the agricultural literature immediately available to the agricultural workers located in this building.

Equipment Needed.

Buildings. I beg to call attention to the recommendation of the Animal Husbandman that a suitable hog barn be built, in which feeding experiments with hogs can be carried on. The Station should be doing some work along this line, but with the present barn facilities it is useless to attempt any hog feeding experiments. The present dairy barn has been severely criticized from several sources for the lack of adequate ventilation, and for the fact that there is no adequate provision for the housing of the manure. I would recommend that suitable metal ventilators be put in, which it is estimated can be done at a cost

of $250. Plans have been prepared by Prof. Taylor for a manure shed 33x20 feet, with cement floor and carriers running thru the alley-ways of the barn and into this shed, which it is estimated would cost about $366. At the present time it is expected that the manure be hauled every day or two but it is frequently desirable to have on hand a quantity of manure for dressing land for experimental work and it is both unsightly and unsanitary to have this accumulate at the end of the barn.

The botanist and the chemist are in immediate need of a greenhouse, in which plants can be grown thruout the season. The botanist needs this for work on plant diseases and the chemist for studies in the relation of plant growth to the chemical composition of the soil. It does not seem feasible to use any of the present greenhouses for this purpose. Such a greenhouse might readily be attached to Nesmith Hall and could probably be built and equipped for about $1,500.

It has been impossible for the dairyman to carry on any experimental work at the Station owing to the lack of room and equipment in the present creamery building. If experimental work is to be carried on in dairying, we must have a building with facilities for such work. A mere creamery building will not furnish such facilities. It would seem that the dairy interests of New Hampshire are sufficient to warrant this Station making the dairy problems one of its leading lines of investigation, but nothing in the line of dairy manufactures can be done until a suitable building is provided.

LAND.

With the amount of land now devoted to sheep pasturage, there has been an insufficient amount of pasture for the dairy herd on the college farm during the past two seasons. Much of the pasture on the farm is of very little value. It has been necessary during the past season to rent pasture for the sheep, and this will continue to be necessary unless more pasture lands can be secured for the work of the Station. The renting of pasture not only involves some expense but it is exceedingly inconvenient for the herdsmen to have the flocks separated in several localities, and as the station is hardly warranted in properly fencing rented land, the danger from injury by dogs is increased. There is also practically no land available on the college farm which is suitable for experiments in corn culture such as are now being carried on by the Agronomy department with ear row tests of corn and similar work, as it has been difficult to find over a fraction of an acre of similar soil any place on the farm.

It has been necessary, in order to carry on experiments in fruit culture, to rent an orchard at Packer's Falls for a term of ten years. Both the writer and the horticulturist have examined all parts of the college farm as regards its adaptation to growing a permanent orchard for experimental work, and there seems to be no land either suitable or available for planting an orchard of reasonable size which might in the future be used for experiments in fertilization, spraying or the culture of the apple. In the future fruit growing will be a larger industry in New Hampshire than it is today and it would seem that it is high time for the Station to be planting an orchard which will be available for work in years to come, for orchards cannot be created in a day and there are practically no orchards within a reasonable distance of the station, available for such work. It is evident that a considerable addition to the land available for the work of the station should be provided in the near future.

Exhibits.

The Station made exhibits at both the Concord State Fair and the Rochester Fair in September, 1908, and at the Union Grange Fair, Plymouth, N. H., October 6, which attracted considerable favorable attention. The principal features were demonstrations of a working home dairy and of packing apples in boxes and pruning young fruit trees. Specimens of various injurious insects, plant diseases, different varieties of grains and fodder crops, fertilizers and feeds, as well as products of the gardens and farm were shown. Circular No. 6 was prepared for distribution at these fairs and it is trusted that as a result, the agricultural public has a better understanding of the work of the Station and will be brought into closer touch with it.

Recommendations.

Publications. At the present time the funds available for the publications of the station are entirely consumed by the publication of experiments and investigations at this station. During the past 20 years there has been an immense amount of experimental work done thruout the country, much of which is of equal or more value to New Hampshire farmers than that carried on here, but which having been published by other stations does not come to the attention of our residents. Much of this work has now become part of the best agricultural practice and still, relatively few New Hampshire farmers are making use of it. Time and again the desirability of publishing a bulletin upon some line of work of which this station has made no par-

ticular investigation arises, but our resources do not warrant such a publication. In a majority of the states the state government is paying for the publications of the Experiment Station either by direct appropriation or by ordering them printed by the state printer. Inasmuch as no appropriation has ever been made by the State of New Hampshire for the work of the experiment station, I beg to suggest that the Board of Trustees lay this matter before the next legislature, endeavoring to secure the printing of the station publications by the state, thus enabling us to publish more of value to New Hampshire farmers, and thus relieving the Hatch Fund to a slight extent.

Demonstration Experiments. The New Hampshire Agricultural Experiment Station has been supported almost wholly by the federal government for the past 20 years, having received from the Hatch and Adams fund about $325,000, the only other income being from the analyses of fertilizers and feeding stuffs for the State Board of Agriculture. Much work of very real value has been accomplished and published, but we are often led to question whether the farmers of New Hampshire, as a whole, have made the best use of this institution maintained in their interest. It is undoubtedly a fact that many of its publications are unread and many more unheeded, and as suggested above, the publications which have been issued cover merely the investigations of this station. During the same period at least $15,000,000 has been expended by the various state experiment stations aside from the immense appropriations now being made to the national Department of Agriculture, as a result of which the art of agriculture has been revolutionized during this period and the process is still going on. If it is a fact that the farmers of New Hampshire are not putting into practical use the results of this work to the extent which they should to secure the best returns from their business, and to insure the general prosperity of the state, the question arises whether we cannot in some way devise means for bringing them into touch with the work of the experiment station and bringing the results of the work of this and other experiment stations to their immediate attention in such a way as will lead them to make use of it. It is the writer's firm belief that the state needs such work at the present time very much more than it needs scientific investigations, for it is of very little value to New Hampshire for us to conduct even the best scientific investigations if the results are to be unheeded.

Two types of work might be carried on by this station with

undoubted promise of success for the betterment of New Hampshire agriculture.

Demonstration and co-operative experiments. Experience in all parts of the country has demonstrated that practical demonstrations of better farm methods are of immeasurably more value in securing the adoption of such methods by the farmer, than is the free literature sent him in abundance or the numerous addresses which he hears at farmers' institutes and other farmers' meetings. This has been most thoroly demonstrated by the work of the U. S. Dept. of Agriculture in the south, but has also been repeatedly illustrated elsewhere and has been shown to be true in our own experience in this state in what little work we have done co-operatively with fruit growers and dairymen. The Station should be able to take a number of the old orchards which still have possibilities in them, and demonstrate by spraying, pruning and cultivation, what can be done for them and what profit there is in fruit growing with up to date methods. Much the same line of work might well be carried on with the packing and growing of vegetables and potatoes. The hay crop is the principal crop of the state, 83 per cent. of the area devoted to crops in New Hampshire being in hay. But we realize only $10 per acre from it, with a yield of 9-10 of a ton per acre. A larger proportion of the cultivated land is in hay in New Hampshire and the crop yields less per acre in New Hampshire than in any other eastern state except Maine. This is very largely due to the fact that fields are often left in hay for 8, 10 or 15 years, and it is the experience of all practical men, that the amount and quality of the crop usually decreases steadily after about the sixth year. If demonstrations made by this station could secure an increase in the hay crop of 1-10 ton per acre for the state, it would mean an increase of $600,000 annually in the value of New Hampshire's hay crop. If a large number of small demonstration experiments were made in co-operation with local granges, the value of frequent rotations and proper fertilization of hay land could be so completely demonstrated and so thoroly proven that there is no question that an even greater increase in the yield than this, could be secured. In the state of Iowa the average yield per acre of corn has been increased several bushels in the last few years thru the work of the state experiment station in demonstrating the methods of seed selection, which has meant an increase of over $10,000,000 annually in the value of the crop in that state. When a sta-

tion can do work of this kind there is no question that its maintenance is worth while, and if its recommendations can be so proven, there will be practically no question upon the part of the farmer or of the general public as to whether money appropriated for such work is worth while.

Survey Work. Complaint is heard on all sides of the lack of profit in agricultural pursuits in New Hampshire. Yet in all lines of agricultural industry there can be found many men scattered thruout the state who, without unusual opportunity or resources, have made an eminent success of their chosen line of agricultural work and if not becoming wealthy are making an exceedingly comfortable living. The success of these men disproves the pessimism of many who lack their ability. There is no question that a study of the methods employed by such men would be of as much value to the agricultural interests of the state as are many of the investigations carried on here or elsewhere. Again it is highly desirable to know just what crops are being grown in various portions of the state, how they are being grown and just where in their culture the profit or loss occurs. This has been done by us to some extent in a survey of the apple orchards of southern New Hampshire, which is still uncompleted, and a survey of the farm dairy methods is now being made. Such work is necessarily slow and costly but when carefully done it shows conclusively the methods in use and how profits are being made or losses sustained. With such data in hand the station can plan its investigations and can make demostrations which will show the more profitable methods and can base such demonstrations not only on its own work but by pointing to the work and success of practical men who have achieved results thru their own efforts. Such work is now being carried on by the U. S. Dept. of Agriculture and is being taken up in several other states.

I would urge that sufficient appropriations be secured so that the station may be provided with funds for carrying on such demonstrations and co-operative experiments and agricultural surveys. No other agency in the state is as suitably organized or equipped for doing such work. That the time is ripe for it can be readily appreciated by anyone who will visit the farmers, dairymen and fruit growers of New Hampshire, as representatives of the station have done during the past year, and note the need for such work and the desire on their part that we should be about it.

INVESTIGATIONS.

The investigations and experiments of the various departments completed and now in progress are discussed fully in the reports of the heads of the various departments, which are submitted herewith. Several pieces of work have been reported in bulletins published within the last two years, the nature ot which is sufficiently indicated from the titles cited above.

Respectfully submitted,

E. DWIGHT SANDERSON,
Director.

DURHAM, N. H., Nov. 1, 1908.

NINETEENTH ANNUAL REPORT TO THE UNITED STATES GOVERNMENT OF THE HATCH FUND

FOR THE YEAR ENDING JUNE 30, 1907.

Receipts.

Cash received from United States treasurer	$15,000.00

Expenditures.

Cash paid for	salaries	$7,907.63
	labor	2,641.24
	publications	1,195.87
	postage and stationery	152.32
	freight and express	189.59
	heat, light, water and power	222.25
	chemical supplies	124.08
	seeds, plants and sundry supplies	591.78
	fertilizers	231.02
	feeding stuffs	20.17
	library	229.06
	tools, implements, and machinery	434.00
	furniture and fixtures	56.17
	scientific apparatus	213.09
	live stock	206.17
	traveling expenses	453.22
	contingent expenses	16.16
	buildings and land	116.18
		$15,000.00

SECOND ANNUAL REPORT TO THE UNITED STATES GOVERNMENT OF THE ADAMS FUND

FOR THE YEAR ENDING JUNE 30, 1907.

Receipts.

Cash received from United States treasurer	$7,000.00

Expenditures.

Cash paid for salaries	$4,556.60
labor	589.19
freight and express	131.44
chemical supplies	16.44
seeds, plants, and sundry supplies	385.89
feeding stuffs	146.93
tools, implements and machinery	14.90
scientific apparatus	615.26
live stock	105.00
traveling expenses	93.22
buildings and land	345.13
	$7,000.00

SUPPLEMENTARY STATEMENT OF FUNDS OTHER THAN THE HATCH AND ADAMS FUNDS

FOR THE YEAR ENDING JUNE 30, 1907.

Receipts.

Cash received, analytical fees, etc	$2,012.42

Expenditures.

Cash paid for labor	$265.87
heat, light, water and power	500.00
seeds, plants and sundry supplies	20.40
library	135.50
scientific apparatus	748.86
live stock	122.69
buildings and land	53.26
balance	165.84
	$2,012.42

TWENTIETH ANNUAL REPORT TO THE UNITED STATES GOVERNMENT OF THE HATCH FUND

FOR THE YEAR ENDING JUNE 30, 1908.

Receipts.

Cash received from United States treasurer	$15,000.00

Expenditures.

Cash paid for salaries	$7,620.66
labor	2,543.22
publications	747.52
postage and stationery	418.40
freight and express	147.09
heat, light and water	662.58
chemical supplies	40.66
seeds, plants, and sundry supplies	615.53
fetilizers	138.75
feeding stuffs	41.01
library	664.60
tools, implements, and machinery	133.40
furniture and fixtures	303.16
scientific apparatus	176.15
contingent expenses	15.00
traveling expenses	498.49
buildings and land	233.78
	$15,000.00

THIRD ANNUAL REPORT TO THE UNITED STATES GOVERNMENT OF THE ADAMS FUND

FOR THE YEAR ENDING JUNE 30, 1908.

Receipts.

Cash received from United States treasurer	$9,000.00

Expenditures.

Cash paid for salaries	$5,516.88
labor	1,053.21
freight and express	34.30
chemical supplies	92.82
seeds, plants and sundry supplies	293.76
fertilizers	67.28
library	134.53
tools, implements and machinery	183.50
scientific apparatus	423.82
live stock	598.50
traveling expenses	152.70
buildings and land	448.70
	$9,000.00

SUPPLEMENTARY STATEMENT OF FUNDS OTHER THAN THE HATCH AND ADAMS FUNDS

FOR THE YEAR ENDING JUNE 30, 1908.

Receipts.

Cash received, analytical fees, etc	$1,994.46

Expenditures.

Cash paid for salaries	$241.70
labor	772.76
publications	116.22
postage and stationery	18.88
freight and express	.30
seeds, plants and sundry supplies	15.88
feeding stuffs	401.24
tools, implements and machinery	25.45
traveling expenses	133.69
contingent expenses	1.50
buildings and land	266.20
balance	.64
	$1,994.46

AUDITOR'S STATEMENT.

The undersigned, duly appointed auditor of the corporation, hereby certifies that he has examined the books and accounts of the New Hampshire Agricultural Experiment Station for the two fiscal years ended June 30, 1908; that he has found the same well kept and classified as above, and that the receipts for the two years from the treasurer of the United States are shown to have been $22,000, and $24,000, respectively, and the corresponding disbursements, $22,000, and $24,000 respectively, for all of which proper vouchers are on file and have been examined and found correct.

And it is further certified that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906.

(Signed) C. H. PETTEE,
Auditor.

Attest:
WALTER M. PARKER,
Custodian.

REPORT OF THE DEPARTMENT OF CHEMISTRY.

BY FRED W. MORSE AND BERT E. CURRY.

The Department of Chemistry has been unchanged in its organization throughout the biennial period. Its miscellaneous work has been of the same character as in preceding years. Included in this class of work are the analyses of fertilizers and feeding-stuffs for the State Board of Agriculture in the annual inspection of those goods. The amount of inspection work varies but little from year to year. In 1907, 85 samples of feeding-stuffs and 114 samples of fertilizers were examined, while for the year 1908, 75 feeding-stuffs and 96 fertilizers have been analyzed.

Some miscellaneous materials have been received from individual citizens, and when of public interest they have been analyzed. The work has been limited almost wholly to feeding-stuffs, manurial substances and soils. In the last named, only organic matter and acidity have been estimated.

The department has co-operated with other departments of the station and has made numerous analyses of insecticides for the entomological department and of fungicides for the botanical department. For the last-named it has also analyzed a series of samples of apple twigs and leaves for fertilizing constituents.

The investigations of the department have been conducted almost wholly under the Adams Fund. They have included a study of the manurial requirements of the soils of the college farm, especial attention being given to the element potassium. Several lines of laboratory studies have been conducted to determine the relation of clay and humus to potassium salts and lime; the effect of various manurial materials on the soil potash; the nature of soil acidity; the effect of lime on nitrification in a clay soil; and some preliminary work on the burning effects produced by Bordeaux mixture on foliage.

In following pages, under appropriate headings, there are given the results of these different investigations so far as they are complete. Some are still under way and will require one or more seasons further study to reach any reliable conclusions.

Under the Hatch Fund, the department has co-operated with the Association of Official Agricultural Chemists in the study of methods of cattle-food analysis.

In the analytical work, more especially on the feeding-stuffs and fertilizers, the department has had the assistance of F. W. Woodman, H. F. French, W. W. Evans and W. L. Adams, graduates of the chemical course in the college.

THE POTASH REQUIREMENTS OF A CLAY SOIL.

The types of soil included in these studies make up nearly the entire area of Durham and vicinity. They are of granitic origin and lie upon a foundation of either boulder clay or granite ledge, according to elevation. On the lowest levels the boulder clay becomes the subsoil and forms an important constituent of the top soil, while on the ridges the ledge frequently outcrops. The greater portion of the soil is a clay loam, changing to a sandy clay loam on the ridges and to clay on the low ground.

Analysis of the clay soil in 1893, by the conventional acid method showed an average of 1 per cent. of potassium oxide soluble in strong hydrochloric acid. This would mean not less than 15 tons of potash per acre locked up in the surface foot of soil. Nevertheless, potash salts appeared to produce some benefit on annual crops, such as corn and potatoes, and therefore the potash naturally present was looked upon as unavailable.

Observation, however, developed much practical evidence that the potash of the soil was sufficient for some crops, more especially grass, and that it was practically inexhaustible. In

the vicinity of the college many acres of hay land were known to have been cropped steadily for years with no treatment to renew them, and the yield rose and fell with the character of the season, and was governed by the rain fall. Testimony from practical farmers was obtained to the effect that gas lime and leached wood-ashes produced good results when applied as fertilizer, instead of complete manures. All tended to show that it was possible to make use of the soil's mineral constituents without resorting to the purchase of potash.

Studies were begun in 1905 to determine something about the character of the potash in these soils, and how it could be most readily made use of, and they have continued to the present time, and are not yet completed. But data have been accumulated which make it possible to report a partial solution of the problem.

The work of the first two years was carried on to determine if any relationship existed between the hay crop and the soil on which it grew. By analyzing the grass-crop and the soil upon which it grew, there could be determined the proportional relation, if any, between them. On the other hand, if there were no proportion between potash in crop and potash in soil, it would point to the conclusion that even in the soils poorest in potash, there was a sufficient amount of that element for the plants.

The samples were gathered from different fields on the college farm. A carefully measured square yard was taken as the area from which to cut the grass and to sample the soil. The grass was cut in July just in advance of haying, and dried under cover. The soil sample was taken by boring with an auger to the depth of eight inches, except on the low clay soil, where a depth of six inches always reached the dense sub-soil.

The crop sample after drying, was weighed, chopped up fine, and sub-sampled for subsequent analysis. The soil was dried at air temperature, sifted through a 1-millimeter sieve and the fine soil used for analysis.

The crop-sample was incinerated in a muffle-furnace and the analysis conducted essentially in accordance with the methods of the Association of Official Agricultural Chemists. The mineral constituents of the soil were, however, determined by the conventional fusion methods instead of in an acid solution. This was done because it was desirable to know the possibility of exhaustion of the soil, and it is well known that the strong hydrochloric acid gives neither total constituents, nor available matter. Fusion of the fine soil obtained by sifting through the

standard millimeter sieve was practically complete, as there were but slight gritty residues left in the subsequent solutions.

The following table gives the results obtained for the oxides of potassium, sodium, calcium and magnesium, and the samples are grouped as upland and lowland:

TABLE 1. *Composition of Soil. Lowland.*

Sample.	Potash.	Soda.	Magnesia.	Lime.	*Potassium Sol. in Water.
I	2.28	1.30	0.92	1.03	*15.8
VI	2.47	1.21	1.01	0.88	22.3
VII	2.78	1.40	1.27	1.03	9.9
VIII	3.22	1.08	1.38	0.97	18.0
IX	3.16	1.35	1.42	1.02	21.9
X	3.56	1.49	1.46	1.08	12.1
XIII	3.46	1.10	1.48	0.87	35.1
XV	3.56	0.87	1.66	0.90	22.4
XVI	2.21	1.18	1.81	1.67	16.2
XVII	3.19	0.96	1.24	1.10	6.0
XVIII	3.96	1.36	1.22	0.97	13.1
XXIV	2.59	1.06	1.05	0.87	26.0
Mean	3.04	1.19	1.33	1.03	18.2

*Parts per million of soil.

TABLE 2. *Composition of Soil. Upland.*

Sample.	Potash.	Soda.	Magnesia.	Lime.	*Potassium Sol. in water.
II	2.07	1.83	0.81	1.09	*13.8
III	2.32	1.81	0.82	0.99	11.4
IV	2.40	1.32	1.11	0.94	8.3
V	2.07	1.26	0.87	0.97	12.3
XI	2.75	1.40	1.35	1.01	17.1
XII	2.32	1.29	0.81	1.00	13.4
XIV	2.19	1.22	0.89	0.75	18.2
XXI	2.05	1.74	0.81	0.97	12.5
XXII	2.07	1.17	....	0.83	6.1
XXIII	2.29	1.47	0.77	0.96	18.4
Mean	2.25	1.45	0.91	0.95	13.1

*Parts per million of soil.

The water-soluble potassium was also determined in the air-dried soil by the method of the Bureau of Soils, and the results are given in the last column of the table. The most prominent facts in these results are that both total potash and water-soluble potassium average higher in the lowland soil than in the upland, or may be considered as varying proportionally with the clay. It is also interesting to note that the average ratio of soluble potassium to total potash is the same for the two classes of soils, although fluctuations are wide in individual soils.

In the examination of the crops, determinations were made of the bases included in the soil analyses, and in addition nitrogen and phosphoric acid. The results of the analyses are given in the following tables, where the samples are numbered and grouped as in the soil table:

TABLE 3. *Composition of Crop. Lowland.*

Sample.	Potash.	Soda.	Magnesia.	Lime.	Phos. Acid.	Nitrogen.	Water.
I	0.84	0.20	0.16	0.29	0.41	0.87	10.66
VI	1.02	0.15	0.16	0.37	0.37	0.82	11.10
VII	1.18	0.14	0.13	0.29	0.36	0.57	9.68
VIII	1.29	0.08	0.20	0.48	0.40	0.86	10.45
IX	1.24	0.14	0.29	0.52	0.43	0.98	10.57
X	1.31	0.15	0.29	0.76	0.36	1.16	9.55
XIII	1.27	0.09	0.28	0.78	0.46	0.70	10.41
XV	1.40	0.14	0.33	0.94	0.39	1.12	9.20
XVI	1.65	0.07	0.24	1.00	0.34	1.14	9.35
XVII	0.98	0.10	0.16	0.50	0.40	0.77	12.10
XXIV ...	1.48	0.16	0.15	0.28	0.45	0.78	15.10

TABLE 4. *Composition of Crop. Upland.*

Sample.	Potash	Soda.	Magnesia.	Lime.	Phos. Acid.	Nitrogen.	Water
II	1.46	0.18	0.21	0.51	0.41	0.82	9.48
III	1.01	0.12	0.14	0.28	0.31	0.65	9.43
IV	0.79	0.11	0.19	0.37	0.36	0.78	9.65
V	1.14	0.11	0.17	0.38	0.41	0.75	10.15
XI	1.47	0.09	0.27	0.65	0.40	1.10	10.22
XII	1.08	0.13	0.20	0.54	0.39	1.11	8.57
XXI	1.21	0.10	0.14	0.31	0.37	0.74	10.82
XXII ...	1.01	0.09	0.16	0.29	0.45	0.88	11.02
XXIII ...	1.08	0.08	0.16	0.32	0.38	0.74	12.85

In collecting the samples it was very noticeable that there were marked variations in the character of the herbage, and that the number of different species of grasses and other plants, varied with the age of the sod. On the newer fields, timothy, red-top and clover were practically free from other species, while on the oldest sod, their places had been taken by wild grasses. Yields also varied widely, as is always noticeable in mowing fields of different ages.

No proportional relation could be traced between the composition of the crop and that of the soil. Fluctuations in the percentage composition of the crop apparently depended more on the kinds of grasses composing it. Calculations of the amount of potash removed by the crop did not show defined proportion between soil potash, total or soluble, and that absorbed by growth. These comparisons are grouped in the following table:

TABLE 5. *Comparison of Potash in Soils and Crops. 1905.*

	Soil		Crop		
Sample.	Percent. Potash.	Soluble Potassium.	*Yield of Hay.	Percent. Potash.	Potash *Absorbed.
I	2.28	15.8	*2,576	0.84	*24.37
VI	2.47	22.3	3,929	1.02	45.05
VII	2.78	9.9	4,337	1.18	56.67
VIII	3.22	18.0	2,515	1.29	36.23
IX	3.16	21.9	2,000	1.24	27.85
X	3.56	12.1	1,828	1.31	26.46
XIII	3.46	35.1	3,483	1.27	62.43
XV	3.56	22.4	2,455	1.40	37.84
XVI	2.21	16.2	2,344	1.65	40.48
XVII	3.19	6.0	3,570	0.98	39.75
II	2.07	13.8	2,051	1.46	32.95
III	2.32	11.4	4,042	1.01	45.05
IV	2.40	8.3	4,019	0.79	35.17
V	2.07	12.3	2,803	1.14	35.53
XI	2.75	17.1	5,135	1.47	84.04
XII	2.32	13.4	3,253	1.08	38.39

*Pounds per acre, calculated from sample.

It was noticeable that increased yield was accompanied, as would be expected, by increased draft of potash from the soil.

In 1906 we repeated the study of the composition of the grass crop on seven of the locations used in 1905. The results are given in the table below, omitting all but the data pertaining to potash. The work was corroborative of that of the previous year.

TABLE 6. *Comparison of Potash in Soils and Crops. 1906.*

	Soil	Crop		
Sample.	†Percent. Potash.	*Yield of Hay.	Percent. Potash.	*Potash Absorbed.
VII	3.22	3,322	1.44	47.74
IX	3.16	3,716	1.34	49.72
X	3.56	1,846	1.54	28.60
XVII	3.19	2,310	1.65	38.06
XVIII	3.96	4,065	1.60	64.90
XXIV	2.59	4,461	1.70	75.81
XI	2.75	4,770	1.34	63.58
XIV	2.19	4,312	1.39	59.75
XXI	2.05	4,046	1.11	44.90
XXII	2.07	2,756	0.61	16.81
XXIII	2.29	2,224	0.82	18.24

*Pounds per acre.
†Results of 1905.

Since the drain of potash from this soil was thus shown to be proportional to the yield, an important question arose,

whether with increased yield due to non-potash fertilizers, there would be a decrease in available potash as time went on, or could the residual potash of the soil go into solution rapidly enough to meet increased demands of vigorous plant-growth, and therefore an indefinite series of crops be grown without the application of potash salts.

We were enabled to take up the study of this question in 1907 by means of a series of fertilizer experiments conducted by the Agricultural Department, and can make a partial report of results of two years' study.

The plots were so arranged that every fertilized plot was checked by a parallel plot with no fertilizer, while one-half of every plot was dressed with lime. The areas were one-tenth of an acre in each case. Each plot was seeded with grass in 1906. The fertilizer was applied as a top-dressing, beginning the year after seeding. In 1907 many of the plots were well mixed with alsike clover; but in 1908 it was almost entirely absent. The soil of these plots was of the type included in the lowland group and hence was strong in total potash.

The crops were sampled for analysis on the day they were cut for hay, in both seasons. In 1907 the clover and grasses were so unevenly mixed in the crop that grasses were sorted from clover and separate analyses made of each.

At this time it is possible to discuss the results obtained by the application of potash salts, land-plaster, wood-ashes, and nitrogen, for fertilizers. The discussion will be confined to the results obtained for potash in the crops, as the other constituents of the 1908 crop have not yet been determined.

Effect of Potash Salts.

Potash salts, both muriate and sulphate, gave no appreciable increase in yield of crop or in percentage of potash in either grasses or clover in 1907, while in 1908, except for a slight excess for the crop on sulphate of potash over its adjoining check plots, the results were the same. The addition of 30 and 60 pounds per acre of soluble potash did not increase the concentration of that constituent in the plants.

The water-soluble potassium in the soil was also unaffected, and the potash salts must have been changed into insoluble compounds. Neither grasses nor clover show any increase in percentage of potash due to added potash fertilizers, although the latter crop is supposed to be readily affected by such manuring.

TABLE 7. *Yield and Potash Content on Potash Series. 1907.*

Plot.	Fertilizer.	Yield.	Potash in Grasses. Dry Matter.	Potash in Clover. Dry Matter.	Soluble Potassium in Soil.
11.	None	5,202	2.19	2.93	*6.18
12.	Muriate. 30 lbs. Potash per A.	4,830	2.18	2.89	6.1
13.	Sulphate. 30 lbs. Potash per A.	4,876	2.11	2.55	5.7
14.	None	4,902	2.05	2.40	5.0
35.	None	3,850	1.67	2.02	5.5
36.	Muriate. 60 lbs. Potash per A.	4,176	2.03	2.01	5.8
37.	Sulphate. 60 lbs. Potash per A.	3,814	1.94	2.56	6.6
38.	None	3,904	1.96	2.69	8.2

TABLE 8. *Yield and Potash Content on Potash Series. 1908.*

Plot.	Fertilizer.	Yield.	Potash in Air-dry Hay.	Soluble Potassium in soil.
11.	None	2,814	1.87	*7.2
12.	Muriate	2,016	1.93	7.6
13.	Sulphate	2,452	1.56	7.0
14.	None	2,316	1.33	8.0
35.	None	5,866	1.48	7.9
36.	Muriate	4,776	1.46	9.0
37.	Sulphate	6,192	1.43	8.0
38.	None	5,320	1.65	8.9

*Parts per million of soil.

EFFECT OF NITROGENOUS FERTILIZERS.

In 1907 but one set of plots was sampled, those receiving nitrogen at the rate of 60 pounds per acre. In 1908 two sets were sampled. Although the nitrogen increased the yield at the rate of one ton per acre in 1907 and over one-half ton in 1908, the percentage of potash in the crop averaged fully as high in the heavy crop as in the lighter one. This is strong evidence that there is sufficient available potash to meet the demand of increased crops.

TABLE 9. *Yield and Potash Content on Nitrogen Series. 1907.*

Plot.	Fertilizer.	Yield.	Potash in Grasses. Dry Matter.	Potash in Clover. Dry Matter.
25.	Nitrate Soda. 60 lbs. Nitrogen per A.	5,676	1.65	1.66
26.	None	3,450	1.82	1.49
27.	Sulphate Am. 60 lbs. Nitrogen per A.	5,220	1.79	1.79

TABLE 10. *Yield and Potash Content on Nitrogen Series. 1908.*

Plot.	Fertilizer.	Yield.	Potash in air-dry hay.
1.	Nitrate Soda. 30 lbs. Nitrogen per A......	7,054	1.25
2.	None	5,674	1.28
3.	Sulphate Ammonia. 30 lbs. Nitrogen per A.	6,446	1.54
25.	Nitrate Soda	5,322	1.59
26.	None	3,616	1.61
27.	Sulphate Ammonia	4,292	1.62

EFFECT OF LIME AND ITS COMPOUNDS.

As was stated in the description of the plots, lime was applied uniformly over one-half of each plot, checks as well as fertilized ones. Neither in 1907 nor in 1908 could the least effect be seen in the yield of grass or clover. Height and color were uniform for the entire plot in each instance, hence no samples were taken to determine any chemical effect on the plant. In another way this was studied by securing results from plots which were treated with land-plaster and wood-ashes, respectively.

The wood-ashes produced no results in 1907; but did increase the yield about 500 pounds per acre in 1908. The effect of the application was not perceptible on the composition of the crop. In neither year did land-plaster produce any increased results in yield or in percentage of potash in the crop.

TABLE 11. *Yield and Potash Content on Ashes and Plaster. 1907.*

Plot.	Fertilizer.	Yield.	Potash in Grasses. Dry Matter.	Potash in Clover. Dry Matter.
16.	Land Plaster	5,566	2.07	2.64
17.	None	5,610	2.56	2.45
38.	None	3,904	1.96	2.69
39.	Wood Ashes	4,176	Mixed 2.24 crop.	

TABLE 12. *Yield and Potash Content on Ashes and Plaster. 1908.*

Plot.	Fertilizer.	Yield.	Potash in air-dry hay.
14.	None	2,316	1.33
15.	Wood Ashes	2,678	1.47
16.	Land Plaster	2,398	1.39
17.	None	3,088	1.54
38.	None	5,320	1.65
39.	Wood Ashes	5,902	1.59

So far as these two successive years' study show, it is evident that this soil has sufficient natural potash available for good crops of grass or clover. Applications of potash salts do not perceptibly affect the constitution of the plants, although the amount of soluble potash added would on some soils show marked results on both yield and composition.

Hence the crop and soil studies of four successive seasons, all point to the fact that potassium is not the limiting element in hay production on these strong clay soils. The drain on the soil-potash is proportional to the yield of crop as a general rule; but any treatment which will bring about increased production of the crop may be independent of potash, since the soil shows a capacity to meet any increased demand for that constituent.

A STUDY OF THE REACTIONS BETWEEN THE MANURIAL SALTS AND CLAYS, MUCKS AND SOILS.

INTRODUCTORY.

At the present time much is being said in agricultural literature about acid soils and soil acids. Poor crop yields are an indication that the soil is not in proper condition. This condition may be the result of one, or the combination of several factors. Some of these recognized factors are the physical condition of the soil, the absence of sufficient quantities of the ordinary manurial constituents, the presence of substances deleterious to plant growth and moisture, as well as the general climatic conditions. Certain tests are in general use to determine whether the disturbing factors are due to the presence of acids. According to these tests there are in this section very few soils, indeed, that do not react acid. Lime is generally recommended to sweeten these sour soils, or in other words to neutralize the acids.

The test in general use for soil acids is known as the litmus test and briefly, is as follows: The sample of soil under examination is moistened with distilled water and packed around a strip of blue litmus paper. If after several minutes the color of the litmus has changed from blue to pink, the soil is said to be acid.

A number of soils which give a decided acid reaction toward litmus have come under our observation. On the other hand field tests show that these soils are not in need of lime. In some instances excellent yields of grass were obtained in spite of the acidity. No difference could be detected between the growth on the limed and unlimed portions. At least one acid clay soil has come to our notice, where nitrogenous manures have produced increased yields, while lime, phosphoric acid, and potassium salts have been without any noticeable effect.

The water extract of soils seldom reacts acid, and, unless boiled, almost never alkaline. On the other hand, the water bath residues of the water extract of soils are nearly always

alkaline to phenolphtalein. This is true of the water extract of many soils that react acid and are responsive to applications of lime. We have found here but few instances where these residues were not alkaline. In this connection it might be noted that nearly all pond, spring and drainage waters are alkaline if heated to remove the carbon dioxide. A great many of the pond waters, even when highly colored, yield alkaline solutions when boiled. We have found no surface waters different from these.

A clay, practically free from organic matter, came to our notice. The water extract of this clay was neutral to methyl orange litmus and phenolphtalein, the water-bath residue alkaline to phenolphtalein, and the clay itself, decidedly acid toward litmus. Also when this clay was treated with a sodium cloride solution for a quantitative estimation of its acid content, a strongly acid solution was obtained. This last treatment was made according to the present provisional A. O. A. C. method *for the estimation of the amount of acids in soils. The large amount of acid in solution was decidedly at variance with the amount of organic matter in the clay. The method is based on the assumption that the sodium salt reacts with the organic acids in the soil to form free hydrochloric acid and insoluble organic sodium salts. However, there are no data in evidence to justify this assumption, and, moreover, the effects of chemical reaction between the sodium salt and the inorganic soil constituents, as well as all absorptive properties of the clays, are notably ignored.

These general observations suggested a number of questions of sufficient interest to make a further investigation desirable.

In order to get at the basis of some of these phenomena, and to determine separately the behavior and properties of the clay and organic matter in the soils, we selected a type of clay commonly known as fuller's earth, as a representative of the clays, and a muck as a representative of the organic matter. This particular muck was selected because of its comparative freedom from inorganic material, and, also, because in common with most mucky soils, the salt solution extract was acid in character. The fuller's earth was selected because some preliminary work showed that it had the properties of the ordinary soils, but to a more pronounced degree. This is particularly advan-

*Bulletin 107, Page 20 U. S. Dept. Agr., Bureau of Chem.

tageous because of the facilities afforded when dealing with greater magnitudes than are usually met with in soil studies.

Schreiner & Failyer* have shown that when dilute solutions of potassium chloride are percolated through soils, the potassium is removed from solution. In the same paper it is shown that phosphoric acid is likewise removed from mono-calcium phosphate solutions. They attribute the phenomena to the absorptive or adsorptive properties of the soil. The percolate was examined in the one case for potassium, and in the other for phosphoric acid, but attention is not directed to the other radicals of the salts.

Hall and Gimmingham** show that when solutions of ammonium chloride and sulphate come in contact with clays the ammonia is removed from solution. They show the phenomenon in its final form to be a straight chemical reaction. For every equivalent of ammonia that goes out of solution an equivalent of calcium, magnesium, or some other base goes into solution. No portion of the acids were removed from solution. It is noted that there was no evidence of the removal of ammonia by absorption phenomena. The final solutions carried no iron and aluminum, and were not acid in character. These clays are different from many clays and soils, in so much as the sodium chloride solution extract carries no iron and aluminum. It has been our experience that such conditions are rare. We have found that where a soil or clay carries a high percentage of lime, no iron and aluminum go into solution. There is no evidence to show that these bases do not, however, continue to react with the ammonium salts. Solutions of the alkali salts extract large quantities of lime and usually magnesium from these soils.

According to Hopkins†, when soils are extracted with solutions of sodium chloride, the organic soil acids react with the sodium chloride to produce free hydrochloric acid. This reaction is quantitative, and the free acid can be titrated, and is equivalent to the original amount of acid present in the soil. Veitch‡ has shown that quantities of iron and aluminum are changed to a soluble condition under these conditions, and an acid solution is produced by the hydrolysis of these salts. When a clay free from organic matter gives reactions similar to the ordinary soils, the acid properties must be produced by some action other than the presence of organic matter.

---

*Jour. Phys. Chem. 10. 239, 1908.

**Jour. Lon. Chem. Soc. 91. 677 (1907.)

†Bulletin 73, page 14, U. S. Dept. Agr. Bureau of Chemistry.

‡Journ. Amer. Chem. Soc. 26. 637, 1904.

Reaction Between Clay and Salts.

When fuller's earth is subjected to the tests usually applied to soils, it responds readily to the acid test. The moistened earth reddens blue litmus, and in contact with the alkali salts acid solutions are rapidly developed. These solutions are decidedly acid toward methyl orange. The earth is practically free from organic matter. When the water extract of this clay is boiled or evaporated to dryness, the residue is alkaline to phenolphtalein. Qualitative examination of the sodium, potassium, and ammonium chloride solution extracts discloses the presence of quantities of iron, aluminum, calcium and magnesium, and less amounts of sodium and potassium. Quantitative results† show that the final solutions contain less ammonia and potassium than the original. Quantitative determinations were not made for the sodium, but the same reactions must take place in such solutions.

Reaction Products.

In table 1 the results are given for the changes which take place between fuller's earth and a solution of potassium chloride.

TABLE I.

Amount of KCl removed from solution.

Grams Al_2O_3 in solution	.2554	.5672 grams K
" Fe_2O_3 " "	.2395	.3523 " "
" CaO " "	.3976	.4566 " "
" MgO " "	.0392	.0784 " "

240 c.c. of tenth normal sodium hydroxide were required to precipitate the iron and aluminum. This is equivalent to 0.9486 grams K.

For this experiment 100 grams of clay, 15 grams potassium chloride and 400 c. c. water was used. These show that the clay had removed 1.45 per cent. of its own weight of potassium from solution, and it is certain from other observations that equilibrium had not been reached. In this case the amount of tenth normal Na OH is not exactly equivalent to the amount of iron and aluminum found gravimetrically. Other determinations show that these two ordinarily agree very closely. The amount of potassium removed from solution corresponds closely to the amount calculated from the equivalents. The difference is .0145 gram, which might be accounted for by the undetermined sodium and errors.

†Hall and Gimmingham Jour. Lon. Chem. Soc. 91. 677 (1907.)

In a different solution of potassium chloride 20 c. c. were found to contain .3046 grams of chlorine. After standing in contact with the clay for two days 20 c. c. of the final solution contained .3063 gram of chlorine. This solution carried considerable amounts of the bases already referred to, indicating that large amounts of potassium had been removed. On the other hand no chlorine had been removed from solution, but remained soluble in combination with these bases. Addition of calcium carbonate to fuller's earth, or to soils, prevents the formation of iron and aluminum salts in the extracts, even when made with strong solutions of sodium or potassium chloride.

We have treated a large number of soils with solutions of sodium and potassium chloride, and in all cases the final solutions carry bases not orignally present. A certain amount of lime always goes into solution and often magnesium, iron and aluminum dissolve. In strong limestone soils as much as .2 to .35 per cent. of lime may be replaced by postassium in this way. In the latter soils very little iron or aluminum remains in the final solution. Compared with the average soils the purer clays will react with the larger amounts of the potassium chloride. This difference is due to the fact that the past conditions have been favorable for this action. The decay of organic matter and consequent liberation of these active salts have carried the action, in many soils, well along toward the end.

Rate of Reaction.

In order to show the rate at which the interchange takes place the following series of tests were made: Five 100 gram portions of fuller's earth were weighed into separate flasks. To each of these portions were added 15 grams of potassium chloride and 200 c. c. of water. These were shaken thoroly and left in the pasty condition, with occasional stirring for different periods of time, when 400 c. c. of water were added. After thoro shaking and mixing, the solutions were filtered. The rate of the reaction was followed by titrating the iron and aluminum in solution with tenth normal sodium hydroxide. This method is based on the assumption that the relative amounts of iron and aluminum in the solution remain constant while the reaction proceeds.

Table II. shows the results obtained in these observations. The first column shows the time the portions were left in a pasty condition and the others are self-explanatory:

TABLE II.

Time in Hours.	Amt. of Water in c. c.	Amt. of clay in grams.	No. c. c. of filtrate titrated.	No c. c. $\frac{N}{10}$ NaOH per 100 c. c.	Calculated total c.c. $\frac{N}{10}$ NaOH
5	600	100	100	29.2	233.6
15	600	100	100	29.3	234.4
20	600	100	100	29.3	234.4
44	600	100	100	29.1	232.8
72	600	100	100	29.	232.0
120	600	100	100	29.	232.

These data show that the changes which take place between the potassium and the iron and aluminum come about quickly. Other experiments show that a large part of the reaction takes place during the first few minutes of contact. The iron and aluminum represent the equivalent of about half of the potassium removed from solution.

A second series of experiments were made to determine the effect of increasing amounts of sodium chloride on the solubility of iron and aluminum, the variable in this case being the NaCl; other factors being kept practically constant.

In obtaining this data 50 gram portions of clay were weighed into separate flasks and varying amounts of sodium chloride Na Cl were added. 100 c. c. of water were then added to each portion. These were kept stirred constantly for half an hour when 400 c. c. water were added. After thoro shaking these solutions were filtered, and the iron and aluminum titrated with N-10 NaOH, as indicated in table III.

TABLE III.

Amt. of water in c. c.	Amt. of clay in grams.	Na Cl in grams.	No. c. c. $\frac{N}{10}$ NaOH per 100 c. c. filtrate.	Total c. c. $\frac{N}{10}$ NaOH per each solution.
500	50	1	2.6	13
500	50	2	4.4	22
500	50	6	12.4	62
500	50	8	15.8	79
500	50	10	16.8	84
500	50	13	17.8	89

These data show, that other things being equal, the greater the amount of sodium chloride present, the more iron and aluminum go into solution. This holds until the reaction almost runs to an end, when an increase in the amount of sodium chloride is without effect.

These data are shown graphically in Fig. 1. The amount of sodium or potassium chloride is represented along the line A B, and the equivalent of the amount of iron and aluminum is repre-

sented along A C. The resultant for these combinations is represented along the line A. D. This, as represented, is practically a straight line along A E or until the reaction between the clay and sodium chloride has almost come to an end. Beyond E the amount of iron and aluminum in solution increases more and more slowly.

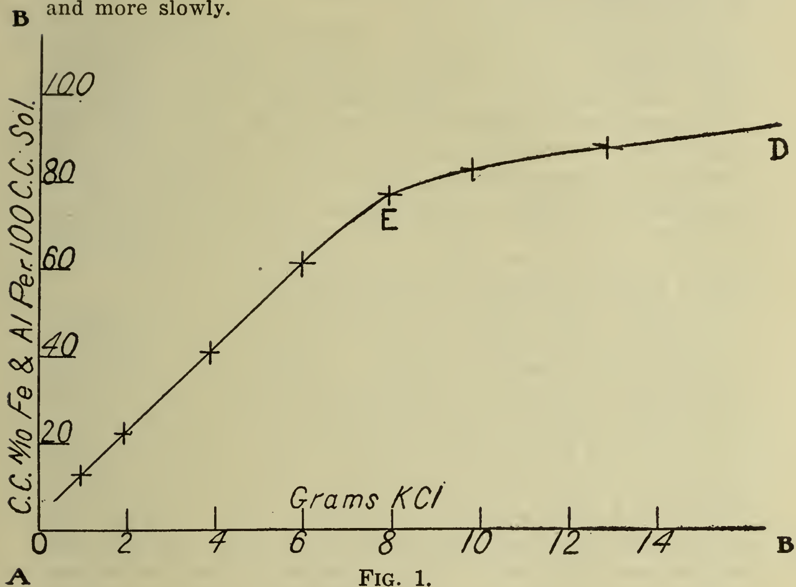


FIG. 1.

At this point the question arose as to what action the clay might have on the iron and aluminum in solution. Standard solutions of the sulphates of these bases were prepared and brought in contact with quantities of clay. After continuous stirring for several hours the solutions were filtered and the amount of iron and aluminum determined in the respective solutions. The concentration of the iron and aluminum had not been altered in the least. From these results it is evident that soils containing soluble iron or aluminum can not be left to right themselves through the action of the clay itself. The deleterious action of these soluble salts and remedies will be discussed in a succeeding paper.

In order to determine more definitely, if possible, how these reactions take place, portions of clay were treated with solutions of ammonium carbonate. In a qualitative way the ammonium carbonate undergoes decomposition with the liberation of carbon dioxide, and less amounts of ammonia. Quantitative ob-

servations show that ammonia is taken from solution, and while the original solution was alkaline to phenolphtalein, the final solution was acid to this indicator. Titrations do not show whether bicarbonate of ammonia was formed under these conditions.

Reactions with Carbonates.

Other portions of earth were treated with solutions of potassium carbonate. The reactions here may be easily followed. When clay first comes in contact with potassium carbonate some of the potassium is withdrawn from solution. The CO_2. which was originally combined with this potassium, is taken up by the remaining carbonate with the formation of bicarbonate. Unlike the chlorine, as already noted, the CO_2 does not combine with the bases in the clay. The formation of bicarbonate continues until half of the potassium has been removed, when the bicarbonate begins to break up with the liberation of CO_2.

A solution of potassium carbonate was prepared of such a strength that when titrated 100 c. c. required 18.1 c. c. N-2 H Cl to break up the normal carbonate, as indicated by phenolphtalein and 36.2 c. c. N-2 H Cl, as indicated by methyl orange. After this solution had been in contact with the clay for a time, it was filtered off and titrated as before. 100 c. c. of this solution required 2 c. c. N-2 H Cl and 20 c. c. N-2 H Cl, with phenolphtalein and methyl orange respectively. These data indicated that practically half of the potassium had been removed from solution, and also that the CO_2, liberated by the reaction had been cared for by the remaining carbonate. Gravimetric analyses showed that the original solution contained .7092 gram of potassium while the final solution contained but .39 gram. These are the same as indicated by titration. The reaction does not stop when all of the remaining potassium is present as bicarbonate. This is seen by treating the clay with a less amount of potassium carbonate. A solution was prepared, such that 100 c. c. required 5.7 N-2 H Cl, and 11.4 c. c. N-2 H Cl, when phenolphtalein and methyl orange were used respectively. After being in contact with clay this solution was filtered and was found to be no longer alkaline to phenolphtalein and 100 c. c. required, but 3.9 c. c. N-2 H Cl with methyl orange. All of the carbonate had been changed to bicarbonate, which in turn was decomposed with the liberation of CO_2.

Almost nothing is known about the physiological effect of bicarbonates upon plant growth. Wheeler* has applied normal

*Wheeler, Rhode Island Station Report, 226, 1897.

carbonate of sodium to acid soils, with good results. Since we do not know how much acid these soils contained, and have no data concerning the absorptive behavior of the soils, it is not easy to judge whether the sodium salt remaining in solution, is there as the normal carbonate, bicarbonate, or in some other combination. Because of the good effects of the applications of sodium carbonate it is safe to assume that either bicarbonate is helpful to plant growth, or what is more likely, that all of the original carbonate had gone through the bicarbonate stage, and finally broken down completely. It is certain that a normal carbonate passes through these steps while being acted upon by the soils.

The following data show conclusively how the clay behaves toward the normal and bicarbonates of sodium and potassium and ammonium carbonate.

In order to determine both the rate of the reaction between the clay and potassium carbonate, and also whether any further evidence could be had to show the nature of the reaction, the following experiments were made. A number of series of practically equivalent solutions of sodium carbonate, potassium carbonate, sodium bicarbonate, potassium bicarbonate and ammonium carbonate were prepared. Equal volumes of these solutions were added to equal quantities of fuller's earth. Titrations were made from time to time in order to follow the reactions. The different series were made up to show what effect concentration might have on the rate and amount of reaction. The results are tabulated in tables IV-XII. For convenience in comparison, the values of the different solutions are expressed in c. c. of half normal solution per 100 c. c.

TABLE IV. *Potassium Carbonate Solution.*

100 c. c. = 36 c. c. N-2 Potassium Carbonate.

Time in hours.	Grams of clay.	c.c. solution.	c.c. N-2 K_2CO_3 in. solution.	c.c. N-2 K_2CO_3 removed.	c.c. N-2 K_2CO_3 left in sol.
2	100	600	216.	97.2	118.8
7	100	600	216.	100.8	115.2
56	100	600	216.	99.6	117.
150	100	600	216.	102.9	113.1

TABLE V.

K_2 CO_3 Solution. 100 c. c.=18 c. c. N-2 K_2 CO_3.

Time in hours.	Grams of clay.	c. c. solution.	c. c. N-2 K_2CO_3 in solution.	c. c. N-2 K_2 CO_3. Removed	c. c. N-2 K_2CO_3 left in sol.
2	100	600	108	61.2	46.8
20	100	600	108	63.	44.7
66	100	600	108	64.8	43.2
150	100	600	108	70.	38.0

Table VI.

$K\ H\ CO_3$ Solution. 100 c. c.=36 c. c. N-2 K H CO.

Time in hours.	Grams of clay.	c. c. solution.	c. c. N-2 $K\ H\ CO_3$ in solution.	c. c. N-2 $K_2\ CO_3$ removed.	c. c. N-2 $K\ H\ CO_3$ left in sol.
2	100	600	216	68.4	147.6
24	100	600	216	73.2	142.8
72	100	600	216	83.4	132.6
150	100	600	216	97.2	118.8

Table VII.

$K\ H\ CO_3$ Solution. 100 c. c.=18 c. c. N-2 $K\ H\ CO_3$.

Time in hours.	Grams of clay.	c. c. solution.	c. c. N-2 $K\ H\ CO_3$ in solution.	c. c. N-2 $K_2\ CO_3$ removed.	c. c. N-2 $K\ H\ CO_3$ left in sol.
2	100	600	108	55.2	52.8
25	100	600	108	56.4	51.6
72	100	600	108	64.8	43.2
150	100	600	108	69.6	38.4

Table VIII.

$Na_2\ CO_3$ Solution. 100 c. c.=30 c. c. N-2 $Na_2\ CO_3$.

Time in nours.	Grams of clay.	c. c. solution.	c. c. N-2 $Na_2\ CO_3$ in solution.	c. c. N-2 $Na_2\ CO_3$ removed.	c. c. N-2 $Na_2\ CO_3$ left in sol.
2	100	600	216	93	123
19	100	600	216	100.2	115.8
63	100	600	216	98	118
150	100	600	216	101	115

Table IX.

$Na_2\ CO_3$ Solution. 100 c. c.=18 c. c. N-2 $Na_2\ CO_3$.

Time in hours.	Grams of clay.	c. c. solution.	c. c. N-2 Na CO in solution.	c. c. N-2 $Na_2\ CO_3$ removed.	c. c. N-2 $Na_2\ CO_3$ left in sol.
2	100	600	108	63.6	44.4
18	100	600	108	66.6	41.4
66	100	600	108	70	38
150	100	600	108	72	36

Table X.

$Na\ H\ CO_3$ Solution. 100 c. c.=36 c. c. N-2 $Na\ H\ CO_3$.

Time in hours.	Grams of clay.	c. c. solution.	c. c $Na\ H\ CO_3$ in solution.	c. c. $Na\ H\ CO_3$ removed.	c. c. $Na\ H\ CO_3$ left in sol.
2	100	600	216	56.4	159.6
21	100	600	216	61.2	154.8
69	100	600	216	70.4	145.6
150	100	600	216	73	143.0

TABLE XI.

$Na\ H\ CO_3$ Solution. 100 c. c.=18 c. c. N-2 $Na\ H\ CO_3$

Time in hours.	Grams of clay.	c. c. solution.	c.c. $Na\ H\ CO_3$ in solution.	c. c. $Na\ H\ CO_3$ removed.	c. c. $Na\ H\ CO_3$ left in sol.
2	100	600	108	55.8	52.2
41	100	600	108	60	48
80	100	600	108	64	44
150	100	600	108	69	89

TABLE XII.

$(NH_4)_2\ CO_3$ Solution. 100 c. c.=36 c. c. N-2 $(N\ H_4)_2\ CO_3$.

Time in hours.	Grams of clay	c. c. solution.	c. c. N-2 $(NH_4)_2\ CO_3$ in solution.	c. c. N-2 $(NH_4)_2\ CO_3$ removed.	c. c. N-2 $(NH_4)_2\ CO_3$ left in sol.
16	100	600	216	72	144
40	100	600	216	78	138
150	100	600	216	85	131

These data show conclusively that similar salts, under like conditions, are affected in the same way by the clay. These things point to a straight chemical reaction. Under like conditions the clay reacts with equivalent amounts of sodium and potassium carbonates and the corresponding bicarbonates; ammonium carbonate is broken down less rapidly than the fixed carbonates. These results are shown graphically in Fig. 2 where the amount of the carbonates reacted with is shown along O B, and the time along O A. As shown here there is a marked similarity between all of the curves. Also the greater part of the reaction takes place immediately. This is particularly true for the higher concentrations of the normal carbonates of sodium and potassium. The first parts of these curves are not shown but are coincident until they start off in the more horizontal direction.

The reactions between the clay and normal fixed carbonates are not accompanied with the evolution of CO_2 until after half the bases have been removed. On the other hand the evolution of CO_2 begins at once, when the reacting substances are $Na\ H\ CO_3$ and $K\ H\ CO_3$ and $(NH_4)_2\ CO_3$.

Nitrate Reactions.

Experiments with ammonium nitrate solutions demonstrate that there is not sufficient iron and aluminum present in the final solution to account for all of the acidity as determined volumetrically. In one instance .1142 gram $Al_2\ O_3$ was necessary to account for the acidity, while .0681 gram was found to be present. In another experiment the calculated amount ot Al_2O_3 was .113 gram, and the amount actually found was

.0381 gram. Selective action must have taken place here, with the result that the base was removed at a much greater rate. This reaction is similar to the carbonate reaction, in so much as the acid radical, at least in part, does not combine with the basic clay radicals. In the final condition free nitric acid is formed in the one case while acid carbonate is formed in the

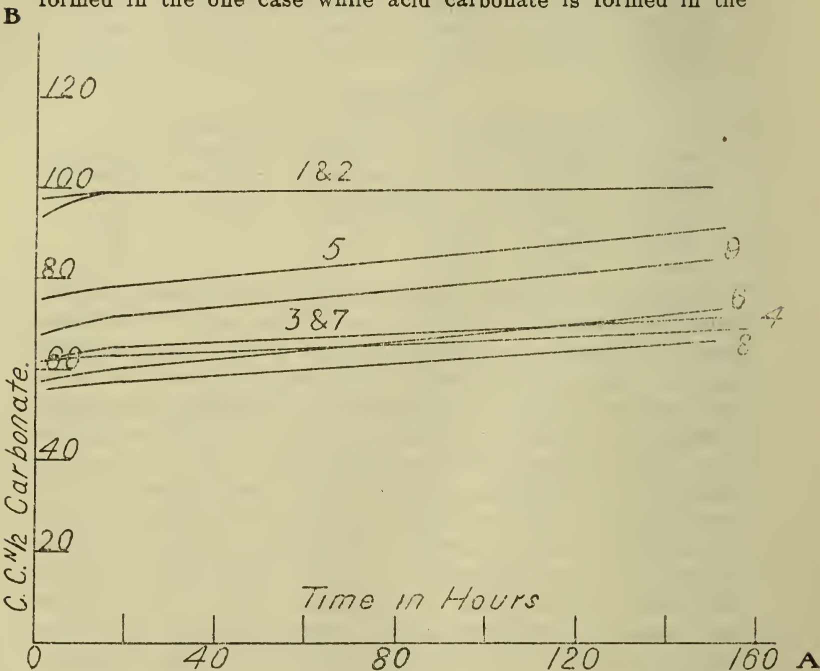


FIG. 2.

other. Potassium and sodium nitrate react quantitatively as does the chlorides of these bases.

While free nitric acid is formed when clay and ammonium nitrate react, it is not easy to see why clay and ammonium chloride should react and not form free hydrochloric acid. The conditions of the reactions are very similar, yet this difference holds for the reaction products.

Little or no selective reaction appears when sodium and potassium nitrates react with the clays.

Reactions with Phosphoric Acid.

So far we have been concerned with salts, only the bases of which were removed from solution. When solutions of potas-

sium phosphate and clay are brought together both the acid and base are rapidly removed. A solution containing .3786 gram potassium and .3 gram phosphoric acid, was shaken with 100 grams of fuller's earth and left over night. The final solution contained .05 gram potossium and .0115 gram P_2O_5. In this case about 1-15 of the original potassium and 1-20 of the P_2O_5 remained in solution. A large part of both the basic and acid radicals were changed to a form insoluble in water.

A solution containing .0378 gram potassium and .03 gram P_2O_5 per 100 c. c., was percolated slowly through a column of air-dried boulder clay soil, which carried a large amount of organic

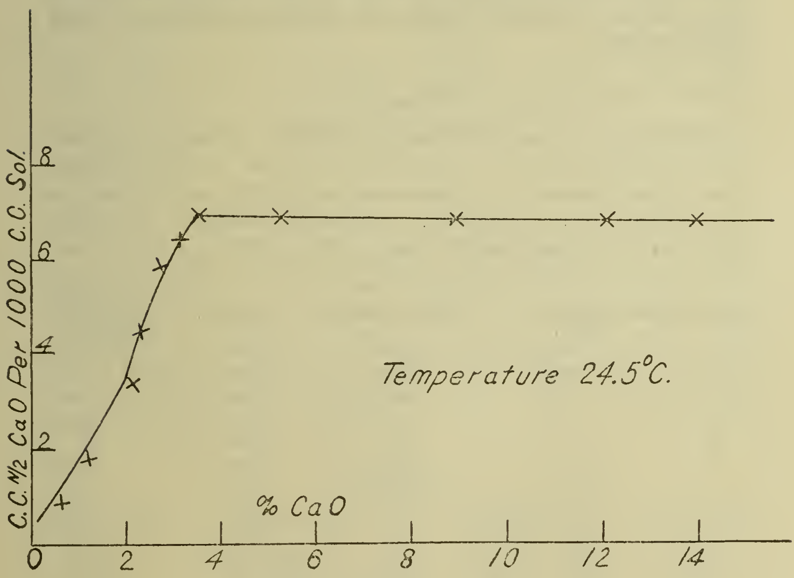


FIG. 3.

matter. The first 100 c. c. of percolate showed no color when tested for phosphoric acid and carried only .001 gram potassium. Here all the phosphoric acid and practically all of the potassium had been removed. The second 100 c. c. of percolate carried only slightly larger amounts of potassium and P_2O_5.

Qualitative examination of the final solutions from both the clay and soil showed that neither the base nor acid radical had been replaced in solution by other salts. The percolate obtained from the boulder clay was almost entirely free from mineral residue. The solutions were neutral to phenolphtalein,

methyl orange and litmus. Incidentally, when potassium chloride solutions were percolated through this same soil, the final solution carried lime, magnesium and aluminum, and was acid in reaction.

Reactions with the Free Bases.

We have already seen how like an acid the clay behaves toward the carbonates. When fuller's earth comes in contact with solutions of the free fixed alkalies and ammonia the bases are neutralized and removed from solution. The affinity seems greater for lime than for any other base and more than 13 per cent. may be cared for before the solution carries any large amount of lime.

Action of Clay on the Solubility of Lime.

A series of solutions were made with 200 c. c. water, 25 grams fuller's earth and CaO, or lime, varying from .05 to 3.5 grams. These were placed in a thermostat at 24.5°C. and stirred for two months, when equilibrium had been reached. The solutions were then analyzed for lime content. The results follow:

No. of Sample.	Grams of CaO.	Grams of clay.	c.c. water.	c. c. N-2 CaO per c.c. of final solution.
1	.05	0.25	200	.02
2	.15	.25	200	.1
3	.3	.25	200	.2
4	.5	.25	200	.35
5	.7	.25	200	.6
6	.8	.25	200	.68
7	1.0	.25	200	.70
8	1.5	.25	200	.66
9	2.5	.25	200	.69
10	3.0	.25	200	.71
11	3.5	.25	200	.68
12	2.0	.00	200	9.27

The CaO in solution was determined by titrating with N—2 hydrochloric acid, and the results are expressed in c. c. N—2 CaO. The data are shown graphically in figure 3. It will be noticed that the amount of CaO in solution in equilibrium with the CaO and clay is only about one-thirteenth as much as where the CaO constitutes the solid phase. If the solid phases across the range, 3 to 14 per cent., be washed with water, the concentration of the CaO in solution will remain

practically constant until the amount of CaO becomes less than 3 per cent. of the clay, when the concentration will begin to drop. The soils must behave in a similar way towards the various *inorganic* salts applied as fertilizers.

An interesting experiment may be prepared as follows for a clay free from organic matter and light in color: If organic matter is present or the clay is colored the colors may be masked. When the clay is shaken with methyl orange a part of the base of the indicator is absorbed and shows an acid reaction. If a dilute solution of caustic soda be added to the mixture and shaken thoroly, the clay will continue to react acid to the methyl orange. The addition of phenolphtalein to the supernatant solution will show this to be alkaline. The addition of too much caustic soda will destroy this acid reaction of the clay. The absorption of dyes has been noted by Parsons*.

This is another instance where both basic and acid radicals are absorbed.

Absorption of NH3 and Iodine.

To show the results of placing fuller's earth in an atmosphere of ammonia and iodine, weighed portions of clay were placed in dessicators. Into one dessicator dry ammonia gas was introduced and crystals of iodine were placed in the other. The watch glasses containing the clay were weighed from time to time and the rate of absorption noted. The weighings are shown in tables XIII. and XIV.

TABLE XIII.

Time in hours.	Amt. of clay.	Amt. of NH_3 in grams.	Per cent. NH3 Absorbed.
0	1.2723	0	0
1-3	1.2925	.020	1.57
4 1-2	1.3038	.0315	2.49
7	1.3076	.0353	2.76
22	1.3087	.0364	2.86

These results are shown graphically in fig. 4. It is quite likely that greater precautions in drying the ammonia gas would show a less percentage absorption. When the clay is placed in the open air the ammonia is liberated quite rapidly and the weight decreases correspondingly.

The results of the absorption of iodine are given in Table XIV., and shown graphically in Figure 4.

*Jour. Amer. Chem. Soc. 29, 598, 1907.

TABLE XIV.

Time in hours.	Grams of Clay.	Grams Iodine Absorbed.	Per cent. Iodine Absorbed.
0	1.0154	0	0
2	1.0456	.0302	2.97
18	1.0516	.0362	3.5
42	1.0600	.0446	4.5

Considerable iodine condensed on the watch glass and the results are higher than they might have been otherwise. Like the ammonia, the iodine volatilizes readily when exposed to the air, and the original weight of the clay is soon reached.

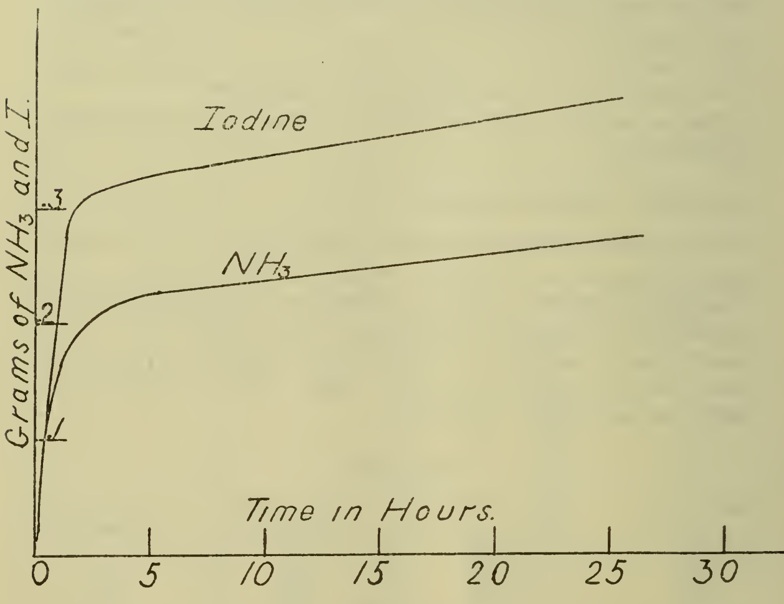


FIG. 4.

These different experiments show that the reactions go differently for the various conditions. There is no evident reason why one salt should react to form a free acid and another to form an acid salt, and another to react in a straight chemical way, while still other reactions seem to be straight absorption phenomena.

The reaction between clay and ammonium nitrate solutions resembles the reaction between carbon black and the same salt and carbon black and potassium chloride solutions. In both of

these reactions an acid solution is produced which must come about by the absorption of the bases with resulting free acids.

So far as the clay constituents of the soils are concerned, there is no reason to believe any of the present methods for determining soil acidity are of any value. On the other hand they may be and are misleading. These statements are supported also by practical observations. We have met with clay soils which change the color of litmus from blue to pink. These soils on the other hand are not acid and are benefited by applications of lime. We have taken samples of soil from immediately under lumps of lime that had been subjected to the leachings of an entire season's rains. These samples reacted to destroy the blue color of the litmus paper just as the untreated soils. In view of these observations, and at the same time bearing in mind the experiments made where only absorption or similar reactions could take place, it seems quite safe to assume that the reactions between clay soils and indicators belong to the same general category. At the same time if a soil were actually acid in character the fact should be brought out with the litmus test. While this is true, the fact that clay soils may give the acid reaction, and at the same time not be in need of lime, must not be neglected. The reddening of blue litmus must be due largely to the action of the clay rather than to the effect of acids. Ordinarily when litmus paper is left in distilled water the blue gradually fades. Indicators are formed by the reaction of an organic acid and an organic base. When these salts come in contact with clay or ordinary soils the base is absorbed or taken from solution. This results in the liberation of a free organic acid which in turn will produce an acid reaction toward the remaining undecomposed indicator. This phenomenon is best shown by stirring a washed filter paper with a solution of litmus. After a short time the solution will have a decidedly acid reaction. On the other hand the same sort of filter paper when stirred with water and filtered, yields a solution neutral to litmus. The only conclusion to be drawn is that the filter paper has removed some of the base from the indicator with the formation of free acid. The reaction between the filter paper and indicator is exactly analogous to the reaction between the clay and bicarbonate of sodium and potassium, in so far as a free acid is liberated.

Mechanical Effects of Salts.

All of the salts referred to have a decided effect upon the colloidal properties of clay. The effect of lime is most notice-

able, while the normal carbonates have the least effect. The water extract is difficult to filter and the filtrate is usually cloudy. The addition of the salts causes the fine particles to subside quickly and make clear filtrates possible.

The effect of the salts generally, is to break down the colloidal properties and to produce a more granular formation of the soil particles. On the other hand the tendency of dilute solutions of the alkalies is to increase the amount of finely divided particles of clay in suspension. The effect of free lime and magnesium is much different from the free alkalies.

The lime is one of the most effective agents in causing flocculation.

Limestone Soils.

A sample of strong limestone soil was treated in the usual way with a potassium chloride solution. Subsequent analysis showed that the lime removed from the soil equaled 0.28 per cent. of the weight of the sample of the soil taken and that about 0.36 per cent. of potassium had been added to the soil. The water extract of this soil was neutral and the residue alkaline in reaction. The potassium chloride solution extract was not acid and carried no iron and no aluminum. The soil, itself, was neither alkaline nor acid to litmus. No free carbonate of lime could be detected with hydrochloric acid. This is a good example of the reactions and conditions met with in a very productive soil. While the lime content of this soil is naturally high, it continues to take up more lime. This is shown by shaking the soil with solutions of lime water, and the amount may equal 3 or 4 per cent. of lime. It is also interesting to note the large amount of potassium which exchanges place with the calcium in the soil. This, in a small way, points out how potassium applied to such soils as fertilizers, will rapidly change over into an insoluble condition. Since in this particular soil the extract is free from soluble iron and aluminum, no deleterious effects would be expected from heavy applications of potassium salts. On the other hand applications of potassium on this soil are of little value in increasing the crop yields.

It is quite possible that some of the acid soils are not productive because of soluble iron or aluminum salts. The soils high in lime do not produce these soluble salts when treated with sodium or potassium chloride solutions. When fuller's earth is treated with potassium chloride solutions and at the same time 2 per cent. free carbonate of lime is added, no iron or aluminum remains in solution. Culture work is now in pro-

gress to determine what effect lime may have on plant growth in solutions containing iron and aluminum salts.

Experiments with Muck.

As has been stated, a number of experiments have been made on muck to determine what sort of reactions take place between organic matter in this form and solutions of KCl and other manurial salts. The muck, itself, reacted acid to litmus paper, and the concentrated extract was found likewise to be acid.

100 grams of the dry muck were shaken with 500 c. c. of a .5 per cent solution of potassium chloride and allowed to stand for 24 hours. The final solution was found to contain the equivalent of .2725 grams of potassium chloride, while .2275 grams had been removed. This solution was decidedly acid, and carried considerable quantities of lime, but no iron and aluminum. 100 c. c. of this solution carried .0492 grams of chlorine, while the calculated amount in the original solution was .0475 gram per 100 c. c.

From these data it is seen that a free acid has been produced from the muck by the action of the potassium chloride solution; potassium has been removed from solution, calcium has gone into solution; the acid radical does not enter into the reaction, or, at any rate, is not removed from solution. It is interesting to note here that the water extract of the muck does not contain any appreciable amount of acid. There is no obvious way to determine whether the potassium is entirely removed by chemical action or whether a part is removed by other phenomena. The presence of lime shows that a part is removed by chemical action. Complete analysis shows that the new bases in solution are present in quantities too small to be equivalent to all of the potassium removed.

Absorption Experiments.

When carbon black is treated with water, as one would expect, a neutral solution is obtained. On the other hand, if a solution of potassium chloride or numerous other similar salts are shaken with carbon black, decidedly acid solutions are produced. Here there can be no question but that the phenomenon is one of straight absorption, where the base is removed faster than the acid radical. In this much the carbon black and muck are similar. The obvious difference between the two, however, is that in the one instance lime goes into solution, while in the other nothing goes into solution.

Muck Extracts.

In order to get this organic matter free from soluble inorganic matter, a large quantity of the muck was extracted with ammonia and filtered. The soluble material was then reprecipitated with hydrochloric acid and repeatedly washed to remove as nearly all of the ammonia as possible. After drying, the mass was pulverized and analyzed. Upon analysis this yielded 97.6 per cent. volatile matter, 2.4 per cent. insoluble inorganic residue and 2 per cent. soluble residue. By distillation over caustic soda .2 per cent. ammonia was found. The larger part of the inorganic residue consisted of sand and mica. The dried extract gave an acid reaction with methyl orange. This reaction was not changed by a continued temperature of 100, and hence must be due to the organic acids and not to residual hydrochloric acid.

When 22 grams of this extract were shaken with 400 c. c. water containing .8 gram potassium chloride, at the end of four days 100 c. c. of the solution contained .1768 gram potassium chloride. This showed that the potassium had been removed equivalent to .0928 gram potassium chloride. In other words the organic matter removed about .2 per cent. of its own weight of potassium from solution. The capacity for removing lime is much greater but has not been determined quantitatively.

A quantity of the organic matter was shaken with a solution of potassium phosphate containing 300 parts P_2O_5 per million. At the end of three days no P_2O_5 had been removed from solution. The original muck, however, removed P_2O_5 in quantities from the same solution. There is a wide difference between the two portions of organic matter because of the quantities of lime and peaty material in the untreated muck. These might remove the phosphoric acid either by absorption or chemical combination. Also the extract was much more acid in character.

Hall and Gimmingham* have shown that muck or peat will remove ammonia from solution. Dumont† has shown that soils will remove mono-calcium phosphate from solution. He decides that humus is a very important factor in the absorption. The greater the ratio between the calcium and the humus, the greater is the absorptive capacity of the soil. When the humus was removed by incineration the absorptive capacity was decidedly decreased.

*Jour. London Chem. Soc. 91. 677 (1907).

†Compt. Rendu Acad. Sc. 132. 443-7 (1901).

Our observations show that the muck extract, which should be very largely humus, does not remove $P_2 O_5$ from solution. It is quite true that this extract is acid in reaction, and under these conditions we would not expect the removal of the $P_2 O^5$. The absorption of $P_2 O_5$, noted by Dumont, must have been due to the inorganic bases in the organic compounds or to the clay itself. Observations already noted show that clay will remove $P_2 O_5$ as well as lime, from solution. It is not at all certain that Dumont's observations would show that the humus constituted the important factor in the removal of $P_2 O_5$. It is not certain what effect the incineration might have on the absorptive properties of the clay constituents. We have noted that incineration of some fairly pure clays reduced their absorptive capacity for bases to a marked extent. From our experiments it is very certain that the organic acids do not have to do with the removal of the phosphoric acid. We can account for the removal of this radical without bringing the organic matter into the reaction at all. Dumont has not shown that the decreased capacity of the soil for phosphates might not have been due to changes effected by heat.

Soil Extracts.

Ordinarily soil extracts carry only small quantities of organic matter. The same is true if a strong solution of sodium or potassium chloride be used. Electrolytes, other than the free alkalies, cause the precipitation of organic matter from solution. The presence of calcium and magnesium salts therefore make the amount of organic matter in the same solution necessarily low. Calcium salts and lime will completely precipitate the organic matter from a slightly ammoniacal solution. Magnesium is almost as effective in this respect. Soil extracts made by solutions of potassium chloride carry no more organic matter than the water extract, largely because of the increased amount of soluble calcium salts. We would expect the amount of soluble organic matter in limestone soils to be very low, but we have, as yet, no definite information about this interesting conjecture.

In this paper we have shown how the reactions go when clays and soils react with the manurial salts. We have divided the soil as nearly as practical into the two components, organic and inorganic, in order to reduce the work to simpler terms.

We have shown that—

1 The water extracts of most soils, drainage, pond and lake waters, are alkaline when boiled.

2. Clays and clay soils extracted with water yield alkaline solutions when free from carbon dioxide.

3. Most clay, clay soils and muck, and some other soils yield acid solutions when extracted with salt solutions.

4. Clays and soils react with potassium, sodium and ammonia in equivalent quantities when these bases are present as salts. Calcium, magnesium, iron and aluminum constitute the largest amount of reacting bases. With ammonium nitrate the base is removed more rapidly and free nitric acid is left in solution.

5. The amount of iron and aluminum in solution is equivalent to the acid content of these solutions.

6. The presence of lime and carbonate of lime prevents the formation of soluble iron and aluminum, or, what doubtless is more exact, precipitates these bases from solution.

7. The reaction between fuller's earth and the salt solutions takes place rapidly. Veitch has shown that in soils the reaction extends through a greater period of time. The amount of reacting bases depends upon the concentration of the salt solution.

8. The reaction between clays and soluble carbonates results in the removal of the bases from solution and the formation of bicarbonates or free CO_2. The amount of bases removed from solution depends upon the concentration of the carbonate solution.

9. The acid character of the solutions formed in these ways does not demand the presence of an acid to complete an explanation for their formation.

10. Where a free base is present it is simply removed from solution without forming any soluble reaction product.

11. When such salts as potassium phosphate come in contact with clays, soils, or mucks, both base and acid are rapidly removed from solution. There are no soluble bi-products formed during the reactions involved.

12. In the presence of clay the solubility of lime is greatly depressed.

13. The absorptive capacity of volatile substances is shown by the absorption of ammonia and iodine.

14. The absorptive properties of the soils is illustrated by analogy, when filter paper is allowed to react with litmus solution, or when carbon black reacts with salt solutions.

15. The general behavior of muck toward the salt solutions is not unlike that of the clay. The acid character of the salt extract of the muck is due to the absorption of the base or the liberation of free organic acid, or both. Iron and aluminum do not enter into these reactions to any marked extent.
16. The acidified alkali extract of muck will precipitate lime and small quantities of potassium from solution, but will not remove phosphoric acid from solution.
17. In a general way the tendency for clay soils, etc., is to reduce the solubility of bases with which they come in contact.
18. Where iron and aluminum are found in clay or soil extracts, the presence of soil acids is not necessary to explain the character of the solution. In muck and peaty soils the acid character of the salt extracts is largely due to increased solubility of the organic decomposition products.
19. The reactions shown in the paper explain the rapid disappearance from solution when potassium, ammonia and phosphoric acid are added to soils for fertilizers.

We have a number of soils under examination which are not acid in character, but at the same time the water extracts are not alkaline when boiled. The results on these will be found in a subsequent paper.

THE EFFECT OF SOILS ON THE SOLUBILITY OF POTASSIUM.

Percolation experiments made here and elsewhere, show that soils change the potassium of soluble salts into an insoluble form. These laboratory experiments are confirmed in a practical way by field observations.

In the spring of 1907 potassium was applied as a top dressing to grass plots on a stiff, clay soil at the rate of 30 and 60 pounds per acre. Generous rainfalls followed the applications of potassium, and conditions, generally, were favorable for a good growth of the grasses.

Eight weeks after the application of the potassium, samples of the soils were taken from the different potassium plots and the nothing, or check plots. These samples were extracted with water in the usual way for the determination of the soluble potassium. A comparison of the results showed that the extracts from the potassium plot soils carried no more potassium than the extracts from the check plots. The plots were ar-

ranged so that every potassium plot came beside a nothing, or check plot. The results follow below:

Pounds of Potassium added per acre.	Parts of K in extract per million pts. of soil.
00	9.4
30	9.0
30	9.9
00	9.3
00	10.2
60	9.7
60	11.4
00	10.6

These plots were on a very uniform lot of soil and all of the samples were taken at the same time. The first four determinations represent one series, while the second four represent a second series. The two different series were located in different parts of the field. All of the added potassium had been converted into an insoluble form during the time of eight weeks.

In addition to the observations made on the grass plots some data have been taken from a potato field. In this case the soil was a light clay loam with good drainage.

The potatoes were heavily fertilized with potassium salts at the time of planting. The fertilizer was placed in the rows, immediately over the seed, at planting time or about the first of May. The soil in the rows was not disturbed until digging time, the first of September. At this time care was taken not to scatter the soil, but to dig a trench about 12 inches wide, and as deep as the potatoes, and confine the soil to this as much as possible. The soil for a distance of several feet in each of three rows, was thoroughly mixed and sampled. In many places there were evidences of undecomposed fertilizer, which proved to consist largely of mould. The heavy growth of tops had, however, prevented a large part of the rainfall from percolating directly down through the soil immediately beneath. This fact, as well as the lightness of the soil, would tend to prevent the change of soluble salts into an insoluble form. A collective sample of soil was taken from midway between the rows for check purposes.

These samples were extracted with water in the usual way and the soluble potassium determined. The results follows:

No. of Samples.	Parts soluble potassium per million parts dry soil.
1 from row.	21
2 from row.	30
3 from row.	23
4 midway between rows.	7

It is not known just how much potassium had been applied, but these results show that a considerable amount remained soluble at this time. The natural amount in solution as represented by sample 4, is only 1-3 or 1-4 the amount found in the rows. However, the check sample is hardly representative because the upper and best soil had been removed and heaped toward the growing vines, otherwise we would expect a higher value for the potassium. From the data available between 90 and 120 pounds of potassium per acre had been applied at planting time. Either amount distributed immediately in the row should show more soluble potassium than was found, had a large part of it not been converted into an insoluble form.

The different types of soil, the different methods of distribution of rainfall and the different quantities of potassium represent the obvious differences between the two conditions represented. All of these would tend to keep the potassium in a soluble condition for a longer period in the potato field.

The first of August, 1907, samples of soil were selected to represent three soil types. One was taken to represent a strong clay soil, and was largely boulder clay with about 4 per cent. organic matter, and practically no sand. A second sample was taken to represent a clay loam, with about 50 per cent. clay and 3-4 per cent. organic matter. The third sample was a light, sandy loam with about 30 per cent. clay and 3-4 per cent. organic matter. The sub-soil of the last two types is largely clay.

The soils were air-dried and then 200 c. c. water added per kilogram of soil. Different known quantities of potassium chloride were added to each of the samples. The potassium chloride was added in solution in order to secure a more uniform distribution of the potassium. After the addition of the potassium and water the mixture was stirred thoroly and set away in sealed Mason jars for 14 weeks. At the end of this period 120 grams of the mixture was extracted with water, and the amount of soluble potassium in solution determined. The results of these experiments follow below. The amount of potassium chloride added per kilogram of soil is given in the first column, under the different types of soil; the amount

of potassium chloride recovered is given in the second column, and the amount of potassium chloride rendered insoluble is given in the third column. The amount of dry soil was the same for each experiment.

Grams of Potassium Chloride added.	Grams of Potassium Chloride recovered.	Grams of Potassium Chloride made insoluble.
Clay Soil.		
1.50	.520	.980
1.00	.435	.565
.5	.125	.375
.25	.075	.175
Sandy clay soil.		
1.50	.885	.615
1.00	.555	.440
.5	.275	.225
.25	.130	.120
Sandy loam.		
1.50	.990	.510
1.00	.621	.379
.5	.300	.200
.25	.135	.115

These data show how much of the potassium has been changed to an insoluble condition. They also show that the clay soil can, under some conditions, remove from a soluble form about twice as much potassium as the light loam soil. For these three particular types of soils the amount of potassium affected is dependent on the amount of clay present. Further experiments show that after a lapse of more time, less of the potassium can be recovered than at the end of the first period. The conditions are such that circulation of moisture does not assist greatly in the action. Under natural conditions the rainfall and consequent movement of the water will bring these changes about more quickly, and more effectively, as already shown in the grass plots. A succession of light showers would, doubtless, remove very large quantities of soluble potassium in a comparatively short time.

The potassium removed is not carried down into the sub-soil, but enters into combination in place with the soil particles. This is particularly true for the clay soils and to a less extent for the light loams. In a light, sandy soil a large amount of soluble salts would be carried down into the sub-soil by heavy rainfalls. This is readily seen from the amount of soluble potassium left in the potato field.

The percolation experiments already referred to show better than any other way how the reactions go between soils and potassium. In order to get data on this the following experi-

ments were carried on. Columns of dry soil about 14 inches high, were prepared in glass tubes. Solutions of potassium chloride, with 200 parts of potassium per million, were percolated through these soils at the rate of about 60 c. c., per 24 hours. The percolate was collected and analyzed for potassium content.

The soils used in this experiment were of the same type as were used in the jar tests, i. e., clay, sandy clay and sandy loam, the analyses of only the first 200 c. c. percolate are given here. We see from the data at once that practically all of the potassium has been removed from the solution.

Parts K per million in the first	Sandy clay.	Clay.	Sandy loam.
200c.c. percolate.	19	16	24

In other experiments where the solution had percolated through a longer column of soil, the final solution contained no more potassium than was the case when distilled water was percolated through a column of the same soil, or about 9 parts per million. However, all of the percolates carried lime, magnesium, etc., in quantities equivalent to the potassium removed. From the percolation experiments it is evident that, at most, two or three good rains would be enough to change ordinary applications of potassium into an insoluble form.

All of these facts show how quickly and effectively clays remove potassium from solutions or change it over into an insoluble form. This is an argument in favor of light and numerous applications of potassium for either chemical or mechanical effects.

It has been our purpose to establish the fact that the soils do change the solubility of potassium, both in the laboratory and in the field. The rate at which these changes take place has been shown to be very rapid under favorable conditions; also it has been demonstrated that large quantities of potassium may be acted upon.

THE EFFECT OF SOME COMMON CHEMICAL FERTILIZERS ON THE SOLUBILITY OF THE POTASSIUM OF SOILS AND SOIL MINERALS.

SOME NOTES ON THE SOLUBILITY OF POTASSIUM OF SOILS AND SOIL MINERALS.

Feldspars.

In our soils a large part of the natural potash is carried by the feldspathic minerals. The potassium in these minerals becomes available to plant needs through their solubility and de-

composition. Both of these processes are conducted under natural conditions with such a degree of nicety and economy, that the supply not only of potassium but other mineral essentials of plant growth, are conserved for the sustenance of succeeding crops. The conditions under which these economies are effected are now both known and understood. The natural solubility of the minerals is low. The solubility is accompanied by decomposition with the formation of clay as a by-product. In the process of solution and decomposition food is furnished for plant growth. An economic function of the clay by-products, among other things, is the conservation of the soluble plant food. This is made possible by their remarkable absorptive capacity for the plant food constituents in the soil solutions. The low solubility of the soil minerals, together with the absorptive properties of the clays, accounts for the small quantities of mineral residue found in most drainage waters, and also in water extract of most soils.*

The literature is not clear in stating how the soil minerals dissolve. Theoretically there should be little difference between the concentrations of solutions in equilibrium with soils composed of similar minerals. What effect organic matter, which always carries more or less mineral substance, can have on displacing these concentrations, while probably not great, is not definitely known. Also the absorptive and adsorptive properties enter in as other disturbing factors. These cause some variations in the amount of water soluble salts that can be washed from different soils.

At present there are no data to show at what rate readjustment takes place when water is added to soil solutions already under equilibrium conditions. If readjustment takes place quickly, the fact should be easily demonstrated by èxtracting with water two or more samples of the same soil which have been allowed to stand for a few days in contact with different amounts of moisture, other things being equal, and assuming that equilibrium is reached at a fairly rapid rate there should be a difference in the amounts of total solids obtained from equal portions of the respective water extracts. Such appears to be a fact. Experiments of this sort show that when samples of the same soil are kept under constant but different moisture conditions, the largest amounts of soluble matter are obtained from the water extracts of the soils maintained at the higher moisture content. Two samples of the same soil were

*See Morse and Curry. This volume, page 274.

made to have moisture contents of 27 per cent. and 34 per cent., and kept in this condition for four months at the end of this period 125 grams of each were extracted with water to equal a total of 500 c.c. The amount of water supposed to be in equilibrium with the soils before extracting amounted to 34 c. c. in one and 41.6 c. c. in the other, or a difference of a little more than 22 per cent. The extracted solid matter from the soil, with the lower moisture content, amounted to .0515 gram, of which .0350 gram was volatile. The other sample yielded .0600 gram of solid matter, of which .0405 gram was volatile. In these examples the amount of material extracted was almost directly proportional to the moisture content of the soils. This ratio holds for both the organic and inorganic residues. The generality of these relations is substantiated by the following experiments:

Five types of soil, varying from a light sandy loam to a boulder clay, were treated with varying amounts of water. After thoro mixing each portion was transferred to a glass jar and sealed and kept in this condition for 80 days. At the end of this time an equivalent of 100 grams of dry soil was weighed from each jar and water added to bring the total amount up to 500 c.c.. From this point the procedure is the same as outlined in Bulletin 32 of the Bureau of Soils. The total residue was determined by weighing the residue obtained by evaporation on the water bath. The salts obtained in this way are more or less hygroscopic and difficult to bring to constant weight. The mineral residue was determined by heating the total residue over a flame to dull redness. By using platinum dishes the carbon is easily volatilized. The data follow:

TABLE 1. *Weight of Total Residue in Grams Per 100 c.c. Soil Extract.*

c.c. Water per 100 gr. soil	Sandy Loam	Stony Loam	Stony Clay Loam	Silt	Sandy Clay	Clay
10	.0146	.0054	.0123	.0118	.0177	.0160
20	.0082	.0060	.0090	.0072	.0231	.0172
30	.0099	.0054	.0300	.0061	.0211	.0294
40	.0088	.0130	.0400	.0169	.0214	.0314
50	.....	.0154	.....	.0170	.....	.0397

The values for the inorganic matter are shown in Table 2:

TABLE 2. *Weight of Total Residue in Grams Per 100 c.c. Soil Extract.*

ccWater per 100 grs. soil.	Sandy loam.	Stony loam.	Stony clay loam.	Silt.	Sandy clay.	Clay.
10	.0039	.0023	.0036	.0040	.0045	.0052
20	.0031	.0027	.0038	.0031	.0055	.0046
30	.0049	.0028	.0060	.0037	.0058	.0066
40	.0050	.0074	.0077	.0058	.0067	.0086
50	....	.0079	....	.0063	....	.0103

These results do not point to the existence of any definite ratio between the amount of moisture in the soils and the amount of water soluble salts. However, where the percentage of moisture is greatest the amount of water soluble inorganic matter is greatest. In any one of the given soils the amount of soluble matter increases, but not proportionately, with the moisture content. The various soils differ considerably in amounts of soluble salts found in their extracts. Where the moisture contents exceeded 40 or 50 per cent. the results were more of less erratic and in some instances are not reported. At present we have no satisfactory explanation for this.

In order to show that in 80 days approximate equilibrium had been reached, the following data are given in Table 3. In these experiments the amount of moisture was kept constant at 40 c.c. per 100 grams of dry soil, the time factor being variable. These results were obtained by leaving the soils in contact with the same amount of moisture for different periods of time and extracting in the same way as already indicated. While these results are only relative, at the same time it is quite reasonable to assume that they represent the changes.

TABLE 3. *Weight of Total Residue in Grams Per 100 c.c. Extract.*

Time	Sandy loam.	Stony loam.	Silt.	Sandy clay.	Clay soil.
20 min.	.0047	.0058	.0052	.0072	
3 hrs.	.0049	.0084	.0064	.0095	.0080
6 hrs.	.0069	.0091	.0082	.0107	.0118
1 day	.0092	.0090	.0088	.0111	
4 days	.0099	.0116	.0134	.0111	.0123
80 days	.0088	.0130	.0400	.0214	.0314

The inorganic residues for these same solutions follow in Table 4.

TABLE 4. *Weight of Mineral Residue in Grams Per 100 c.c. Extract.*

Time.	Sandy loam.	Stony loam.	Silt.	Sandy clay.	Clay soil.
20 min.	.0016	.0013	.0012	.0018	.0023
3 hrs.	.0013	.0014	.0023	.0042	.0038
6 hrs.	.0027	.0038	.0035	.0046	.0052
1 day	.0038	.0035	.0024	.0037	.0059
4 days	.0032	.0047	.0056	.0049	.0056
80 days	.0037	.0074	.0058	.0067	.0986

These data, particularly the inorganic results, indicate that the first set of data was taken after equilibrium had been established between the soil and moisture. The tables show also that equilibrium is established fairly rapidly. A relatively large part of the salts go into solution during the first few minutes of contact between the soil and moisture. The actual rate at which solution continues is also shown for these different soils. The clay formed by decomposition of the feldspathic minerals, however, introduces factors met with under all ordinary soil conditions, which take place when the moisture content of a soil is increased. By decreasing the amount of soil moisture before extraction, the amount of soluble salts will have decreased. This is due either to the absorptive properties of the clay in the soils or to recrystalization of the salts into an insoluble mineral.

The feldspar minerals do not exhibit any marked absorptive capacity for soluble bases. For this reason they are valuable only as a source of potassium. The slowness alone with which these minerals dissolve insures an almost inexhaustible supply of potassium, while the absorptive action of the clays and organic matter prevent the removal of the dissolved potassium by again rendering it insoluble.

There have been a number of theories advanced concerning the solubility of soil minerals. Two of these may be assumed to represent these differences fairly well. *Cushman maintains that the feldspar dissolves slowly in the soils because continued exposure of the surfaces of the finely divided particles to the solvent action of the soil solutions have caused the formation of protective surface films. These films do not break down easily and the minerals dissolve less rapidly. This theory is supported by the fact that the regrinding of feldspars that have been subjected to the solvent action of water causes a great increase in the rate of solubility. When the surfaces

*Bulletin 32, Dept. of Agriculture, Bureau of Chemistry.

are again filmed over new surfaces may again be produced by regrinding and with a continued high rate of solubility. According to this idea the soil particles due to the continued action of water present only old surfaces, and because of this solution takes place slowly.

Again there is another * theory that the soil minerals are continually dissolving or forming with a tendency toward equilibrium solutions. Under these conditions, with equilibrium approximately established, an increase in the moisture content would cause further solution, while on the other hand a decrease in the amount of water would cause the formation of new minerals or insoluble salts. While the formation of these new minerals has not been definitely established, the idea is in perfect keeping with our present knowledge of equilibrium conditions. When studied under the microscope the soil minerals have sharp, definite, crystal edges. This must be due to recrystalizing processes, otherwise the edges would soon become rounded and the outlines of the crystals undergo marked changes. It is known that salts added to soils as fertilizers, soon lose their identity. Careful work shows that the requirements of growing crops are not the cause of these changes. The bases of these salts go either to form new minerals or are incorporated into the clay as constituents of solid solutions or absorption products.

Numerous references are made, in agricultural literature, to the beneficial effects obtained when soils are treated with applications of lime. It is generally conceded that among other things the action of the lime tends to make the natural potassium more soluble and more available for plant growth. While this conclusion has long been in evidence, no data other than indirectly, have been produced to show that it is necessarily true. In practice other applications are made to the soil in order to produce better plant growth. Nitrogen is supplied in the form of salts, as well as in organic matter. Ordinarily, applications of phosphoric acid are accompanied with gypsum. From this it is at once evident that the application of a complete fertilizer to a soil might be a very complex matter in effect.

*Bulletin 30, Dept. Agr., Bur. of Chemistry.

It is the purpose of this paper to show what effect lime, gypsum and the common manurial salts applied separately, produce on the potassium content of the feldspars. The experiments have been conducted on the feldspars because, as already stated, they are the natural source of potassium, and in this way the undesirable effects of clay and organic matter are avoided. Also, greater effects should be obtained where feldspar alone is treated because of the larger amount of potassium present.

The experiments were conducted as follows: Usually 25 grams of finely ground feldspar, 180 c.c. water and known amounts of lime, gypsum, and the various salts, were placed in glass-stoppered bottles. These mixtures were placed in a thermostat at 24.5 degrees C. and stirred for 7 weeks. At the end of this time the bottles were removed from the shaft and placed on the bottom of the thermostat. After a few days the supernatant solution was pipetted off for analysis. In some combinations the supernatant solutions were not clear and in these cases the solutions were passed through a filter.

In the beginning a number of determinations were made to ascertain the rate at which the feldspar goes into solution. The results of these have not been at all satisfactory because of the difficulty encountered in obtaining uniformly clear solutions. The solutions were freed from the finely divided, suspended feldspar particles by means of a porcelain clay filter. In every case the first portion of the filtrate was discarded. Charges of 30 grams of feldspar with 180 c.c of water were placed in glass-stoppered bottles and stirred at a temperature of 24.5 degrees C. The bottles were removed at stated intervals and the solution filtered. 100 c.c. of the filtrate was evaporated to dryness in a weighed platinum dish ignited to dull redness to remove water and any traces of organic matter, cooled and weighed. The average results are shown in Table II. The time is given in the first column and the number of milligrams per 100 c.c. solution is given in the second column. Distilled water was used as solvent.

Time in days.	Milligrams residue per 100 c. c. sol.	Time in days.	Milligrams residue per 100 c. c. solution.
1-24	120	16	197
1	160	24	200
2	170	30	202
4	175	36	201
8	185	50	205

The data are plotted in Fig. 5 to show the relation of the time factor to the amount of soluble residue. At first the curve is steep but gradually approaches a horizontal direction after about 20 days. The largest amount of solution takes place during the first few hours. As the solution continues the rate decreases slowly as it approximates zero or as equilibrium conditions are reached. From these experiments it is evident that there is a limit to the concentration of mineral solutions. While this is true, it is also shown that a readjustment ought to take place rapidly to correspond to any change in the water content.

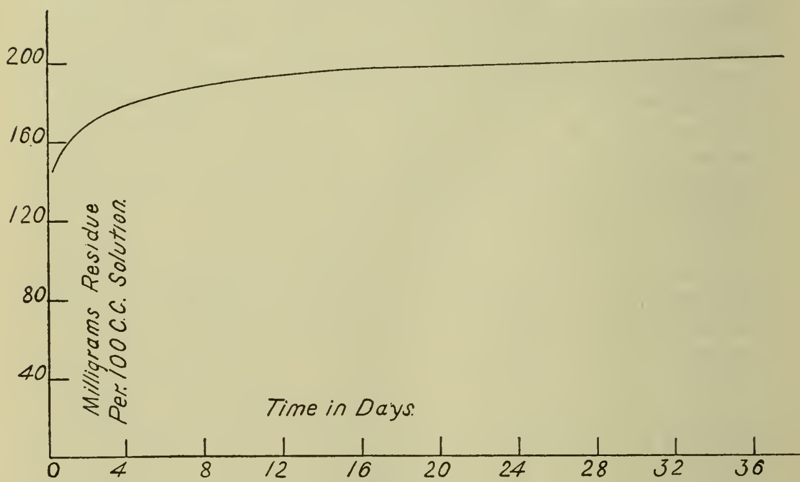


FIG. 5.

Other experiments were conducted as follows: Thirty grams of finely ground feldspar, 180 c.c. water and known amounts of lime, gypsum, sodium-nitrate, ammonia-sulphate, sodium-carbonate and di-sodium phosphate were placed in a thermostat at 24.5 degrees C., and stirred for 7 weeks. At the end of this time the bottles were removed from the stirring gear and placed on the bottom of the thermostat. After a few days the supernatant solution was pipetted off from analysis. In some combinations the supernatant solutions were not clear. In these cases the supernatant solutions were passed through a filter.

It is not certain that equilibrium had in every case been established, but a very close approximation had been reached. This is not, however, of importance since the direction rather than the magnitude of the reaction, is the point in question. The solutions were analyzed for soluble potassium as follows: 100

c. c. of the solution were concentrated to about half the volume, when enough ammoniacal ammonium oxalate was added to precipitate all of the calcium, aluminum, etc. After the removal of the precipitate the solution was evaporated to dryness in the presence of sulfuric acid. The excess of acid and the ammonia was removed at this point by heating to dull redness. The potassium was then precipitated by an excess of platinic chloride solution. After thorough washing with alcohol to remove the excess of platinic chloride and soluble chloroplatinates, the precipitate, together witih the filter, was transferred to a weighed platinum crucible and reduced by ignition. After slight acidulation, the residue was thoroughly washed with hot water and weighed as metallic platinum.

The potassium involved in the reaction was calculated from the amount of metallic platinum.

Table I contains the data for these experiments. In every case 25 grams of finely ground feldspar was stirred with 100 c.c. of water. Other salts were added in different amounts. Time 7 weeks.

TABLE 5.

Reagent added	Amt. of reagent added in grams.	Amt. of K liberated in grams.	Average.	Amt. of K liberated by action of reagent
0	0	.0053		0
0	0	.0058	.0056	0
0	0	.0059		0
CaO	1	.0102		
CaO	2	.0130	.0126	.0070
CaO	2	.0140		
$CaSO_4$	1	.0063		
$CaSO_4$	2	.0067	.0076	.0020
$CaSO_4$	3	.0098		
$NaNO_3$	1	.0101	.0100	.0044
$NaNO_3$	2	.0100		
$(NH_4)_2SO_4$	1	.0100	.0105	.0049
$(NH_4)_2SO_4$	2	.0110		
Na_2CO_3	1	.0080	.0085	.0029
Na_2CO_3	2	.0091		
Na_2HPO_4	1	.0090	.0088	.0032
Na_2HPO_4	2	.0087		

All of the solutions except the checks and those containing sodium phosphate and sodium carbonate filtered readily. The finely divided feldspar particles were separated from the other solutions by filtering through porcelain clay filters.

The data show that so far as the feldspar is concerned, the general effect of the presence of electrolytes is to hasten or increase the rate of solution of the potassium. So far as could be determined there was little or no tendency for the undissolved feldspar to remove any of the soluble potassium from solution.

Lime causes more potassium to go into solution than does any of the other combinations tried. This is probably not because of the alkaline character of the solution, otherwise an equal amount of potassium would have dissolved where Na_2 Co_3 was substituted for the lime. Also there is a marked difference between the action of lime and gypsum. It has been generally supposed that gypsum is about as valuable as lime when applied to soils.

The last column in Table 1 shows the amount of potassium in excess over the average amount found in the solution where water and feldspar had been stirred together. These differences are credited to the action of the various agents which were added to the solutions. The excess, as seen, varies from 35.7 per cent. to 125 per cent., with lime highest and gypsum lowest. The general effect of all of the commonly used manurial salts on the feldspars in the soils tends to increase the available potassium, or, at any rate, to make the potassium dissolve faster.

It has been a time-honored custom to speak of the interaction between lime and the so-called soil zeolytes. Zeolytes are represented by the partially decomposed minerals where the potassium is easily replaced by lime and other similar bases.

In order to determine the rapidity with which these changes take place, we have treated a zeolyte with water, lime and gypsum. A zeolyte, commonly known as apophylite, was reduced to a fine powder by grinding. Portions of 30 grams each were weighed into glass-stoppered bottles. To one portion was added 100 c.c. water, to another 100 c.c. water and 1 gram CaO, and to the third 100 c.c. water and 1 gram CaSO. These were placed in a thermostat at 24.5 degrees C, and stirred for 9 weeks. The series was run in triplicate.

The average of the results are shown in Table 6:

TABLE 6.

Reagent added.	Amount of K in solution in grams.	Amount of K in grams dissolved by action of lime and gypsum.
00	.0029	.0000
CaSO	.0025	.0004
CaO	.0031	.0002

The effect of the lime and gypsum seems to be negligible on the apophylite. The amount of potassium liberated in the nine weeks is very slight. The original zeolyte contained 2.3 per cent. potassium, and less than .5 of one percent of the total

amount was dissolved. Since the differences between the amounts of potassium obtained from the various solutions varies less than .3 of one milligram from the average, all must be ot the same magnitude.

Before making the observations on the feldspar a number of experiments were made to determine the action of lime and gypsum on soils. These experiments have been carried on both in the field and in the laboratory.

Samples of soil were collected from check plots and from plots that had been treated with heavy applications of both lime and gypsum. In the latter samples the soil was taken from immediately under the spots where the lime was still in evidence. The samples were taken two years after the application of the lime. The soil was of the strong clay variety and carried about 3 per cent. potassium oxide. After thorough mixing the samples were shaken with water in the usual way, and the amount of potassium in the extract determined in parts per million of the dry soil. The results on four samples follow:

TABLE 7. *Parts Potassium per Mill. of Dry Soil.*

Sample No.	Limed Soil.	Unlimed Soil.
1	12	13
2	9	8
3	11	11
4	12	10
Average	11	10.5

Practically there is no difference in the amounts of potassium washed from these soils whether lime or no lime had been applied. However, the amount of inorganic residue in the extracts of the limed soils was much the greater. The lime and gypsum had affected the mechanical condition of the soil in so much as the untreated portions were less friable and showed a greater tendency to puddle. At the same time no difference has been noted in the yield of grass on the different plots up to and including the fourth mowing. In the meantime the soil had been subjected to the action of the lime and the freezing and thawing of two winters.

Samples of a clay and sandy clay soil were treated with lime at the rate of 1 and 2 grams per 100 grams of soil, and stirred constantly for 5 weeks with 500 c.c. of water. At the end of this time the solutions were filtered and the amount of potassium determined in each solution. These results follow:

TABLE 8. *Parts Potassium per Million of Dry Soil.*

No. of Sample.	Limed Clay.	Unlimed Clay.	Sandy Clay limed.	Sandy Clay not limed.
1	40	44	36	42
2	48	39	42	38
3	39	44	36	40
4	45	42	38	38
Average	43	42	38	39.5

These results are typical of a number of observations. In some instances there is more soluble potassium in the unlimed samples, while in other instances the limed samples yield more potassium. The averages are so close together that no distinction can safely be made.

Another set of experiments have been made to determine what effect freezing and thawing would have on limed and unlimed soils. Here again no difference could be found except in the mechanical condition of the various soils. The different samples were treated with lime and together with the checks subjected to changes of temperature from 10 degrees to 20 degrees Farenheit. After a number of successive freezes and thaws, the samples were extracted with water and the soluble potassium determined. The results follow:

Sample No.	No Lime—Parts K per mi. dry soil.	Lime—Parts K per mi. dry soil.
1	19.4	19.8
2	18.4	20
3	22.9	23
4	22.	22
5	22.	22
6	23.	20

The data for the gypsum and soils have not been given but are of the same general character as those given for the lime.

In a general way the action of lime and the calcium salts has the same effect on the solubility of potassium, both in the soils and the zeolytes. On the feldspar mineral the effect of lime is to increase the solubility of the potassium. There is at once an apparent discrepancy between these conclusions. It was at once evident that some explanation had to be made for this. Experiments with clay had shown that the clay would remove potassium from a solution of potassium chloride, or any other salt of this base. With this in view we added together 25 grams of clay, and 25 grams of the feldspar, lime, and 180 c. c. of water. These, with checks, were placed in a thermostat at 24.5°C, and stirred for 7 weeks. At the end of this time the solutions were examined for potassium. The results follow:

Bottle.	Grams Feldspar.	Grams Clay.	Grams CaO.	c. c. Water.	Soluble Potassium in grams.
1	0	25	0.0	180	.0012
2	0	25	2.	180	.0009
3	30	25	1.	180	.0060
4	30	25	2.	180	.0052
5	30	0	0	180	.0056
6	30	0	0	180	.0060
7	30	0	1	180	.0126
8	30	0	2	180	.0132

The action of the clay is definitely shown here. The presence of the clay has reduced the amount of potassium in solution more than 50 per cent. The lime, clay, feldspar solutions carry no more potassium than the feldspar water solutions. The clay has changed the conditions of the reaction from the reaction of lime with a mineral, to the reaction of lime with a soil. There is little doubt but what the lime reacts with as much potassium in the one case as in the other, but where clay is present the solubility of the potassium is decreased.

In this connection the solubility of lime in equilibrium with water, and in equilibrium with water and clay, is of interest. At 24.5 degrees C, 100 c.c. of water will carry about 0.129 gram CaO. When clay is added to this system the solubility of the CaO is depressed, and at 24.5 degrees C, 100 c.c. of the solution carries only .009 gram CaO, or about one-thirteenth of the amount where no clay is present. The depression in the solubility of the potassium in the feldspar solutions, caused by the clay, no doubt, is analogous to the depression in the solubility of the lime where clay is present.

An ordinary soil will cause a depression in the solubility of CaO. For an example we obtained a sample of strong clay, limestone soil. This was taken where the limestone ledge lay but a few feet below the surface. The water extract of this soil, when heated, reacted strongly alkaline. On the other hand 100 grams of this soil rapidly decreased the CaO content of a solution from 1.3 to .45 gram. In other words, the CaO content of the solution had been decreased from .119 to .03 gram per 100 c. c. Contact for a longer time would depress this solubility still further.

Summing it up, it may be stated:

In general, the amount of water soluble salts in a given soil is dependent on the amount of soil moisture, and the time during which the soil and moisture have been in contact, providing, of course, that the time has not been sufficient to establish

equilibrium. Equilibrium having been established, the amount of solute depends on the amount of moisture.

The rate at which the feldspar dissolves is fairly rapid until approximate equilibrium is established.

The rate at which the soil minerals dissolve decreases as equilibrium is approached.

The effect of these solvents is to increase the amount of soluble potassium in the feldspars.

Time produces the most pronounced results.

These solvents do not increase the amount of water soluble potassium in soils.

We have not been able to replace the potassium in zeolytes, (apophylite), by stirring the ground mineral with lime.

The results are different, depending on whether soil or mineral is subjected to the action of these solvents. The difference is due to the presence of clay in the soils.

The action of the clay is not dependent on temperature.

The addition of clay to a solution of CaO depresses the solubility of the CaO. This action, apparently is analogous to the depression of the solubility of potassium.

From a laboratory point of view, the effects of lime on a soil are more mechanical than chemical. The mechanical effects are easily noted. The chemical effects cannot be followed.

In a practical way the mechanical effects due to the action of lime may or may not produce greater crop yields. At present we cannot make predictions either way with any great certainty.

Neither field nor laboratory work has been able to establish any relation between applications of lime to soil and the amount of water soluble potassium in the soil moisture.

DEPARTMENT OF AGRICULTURE.

FRED W. TAYLOR.

I. ORGANIZATION AND EQUIPMENT.

The only important change in the organization of this department since the last report, was its division July 1st, 1908, into the two departments of Agronomy and Animal Husbandry. This division has been made in nearly all similar institutions, and seemed justified here on the ground that the work and interests of the two departments were essentially different and not closely allied. It is believed that the change will add to the

efficiency of both departments, since there can be a greater concentration of work and energy along the respective lines.

Prof. E. L. Shaw, who had been assistant in agriculture, and who had direct charge of the animal husbandry work since Sept., 1903, resigned his position July 1st, 1907, to accept a similar one with the Bureau of Animal Industry at Washington, D. C. On July 1st, 1907, Mr. Jasper F. Eastman, (Mass. Agr'l College '07) was secured as assistant in Agronomy and has had charge of the field and laboratory work in that line. Several changes have been made during the past two years in the position of herdsman, but on April 1st of this year we were fortunate in securing for that position Mr. J. C. McNutt, (Ohio State Univ. '07), who has had much training in the judging and handling of livestock. Mr. Geo. S. Ham, who has capably filled the position of farm foreman for the past three years, has tendered his resignation, to take effect November 1st.

In the matter of equipment, the most important additions have been the erection of a sheep barn and the purchase of sheep for the sheep breeding work, which is now being prosecuted under the provisions of the Adams Fund. For the work in grain production a self-binder, a thresher and a fanning mill have recently been purchased.

II. AGRONOMY.

The work of the Agricultural Department naturally falls under two heads; i. e., agronomy and animal husbandry. The agronomy work having to do with soils, the production of field crops, and the use of fertilizers and manures, is reported under the following heads: 1. Soil Tests, 2. Corn Breeding, 3. Grain Crops, 4. Fertilization of Grass Land, 5. Forage Crops, 6. Seed Testing, 7. Co-operative Work.

1. Soil Testing.

In order to try the practicability of the so-called "wire basket" method of determining the manurial requirements of soils, a series of tests was conducted in the laboratory and green-houses last winter. The object of these tests was two-fold;—first, to determine the maximum differences, both in the transpiration and green weight of the plants with and without manurial elements; second, to determine the closeness of agreement between the results obtained from the basket method and those obtained from field plots on the same type of soil.

Four types of soil were taken from various fields of the college farm, i. e., stony loam, sandy loam, clay loam and clay. In

the treatment and handling of the baskets, soils, fertilizers and plants, the detailed directions given by the Bureau of Soils in Circular No. 18 were carefully followed. The plants used were wheat seedlings and were allowed to grow from 30 to 40 days, there being four duplicates of each treatment of the soil. The manurial treatments were as follows:

No. 1. Untreated.
No. 2. Dry manure (5 tons per acre).
No. 3. Lime, (1 ton per acre).
No. 4. Nitrate of Soda (400 lbs. per acre).
No. 5. Muriate of Potash (120 lbs. per acre).
No. 6. Acid Phosphate (430 lbs. per acre).
No. 7. Nitrate of Soda (200 lbs. per acre).
Acid Phosphate (215 lbs. per acre).
No. 8. Nitrate of Soda (200 lbs. per acre).
Muriate of Potash (60 lbs. per acre).
No. 9. Acid Phosphate (215 lbs. per acre).
No. 10. Complete fertilizer (320 lbs. per acre).
No. 11. Complete fertilizer plus 2,000 lbs. of lime.
No. 12. Wood ashes (900 lbs. per acre).

As regards the first object of the test it was found that even with the most careful manipulation, no marked differences were shown, either in the growth or transpiration of the plants variously treated. Greater differences were frequently found between duplicates of the same treatment than between different treatments. As regards the second object, it was found that with three of the types of soil no concordant results were obtained. With one type, the clay soil, the basket results agreed very favorably with those obtained on the same type with grass plots in the field.

The general conclusion, therefore, seems to be that the method, while simple and of comparatively easy operation, fails to determine with any considerable degree of accuracy the manurial requirements of our common types of soil. It is probable, however, that with soils markedly deficient in humus or in one or more particular elements, the method would have some value in making the determination.

2. Corn Breeding.

This work has now been in progress for two years, with the object in view of securing a strain of dent corn which will be highly productive and of early maturity. The so-called "ear row method" is being used for the selection work in connection

with a careful scheme of breeding. The ear row test is a simple method of determining the comparative productivity of individual ears of corn by planting the kernels from each ear in a separate row of fifty hills. Each row is then cut and husked separately, and a record of its yield is kept. By saving out some of the kernels from each ear at planting time remnants are secured. The following year the remnants of the two best producing ears in the test are planted in a small, well-isolated plot, and by detasseling the stalks from one of the remnants, a direct cross between these two is secured.

By a repetition of this process for a few years, a strain of corn will be obtained whose pedigree will be known and whose ancestry will have been proved to be good producers. From the work thus far completed, it is evident that there is even a greater variation in the productiveness of individual ears of corn which are externally similar than there is between dairy animals of similar characteristics and appearance. For example, last year, which was a most unfavorable one for corn, the yields from fifty selected ears varied from 11 to 27 bushels per acre. While the testing of varieties is interesting and important, the real method of corn improvement, and the one to which we must look for results, is selection and breeding.

3. Grain Crops.

During the season of 1907 the comparative yields and maturing qualities of 23 varieties of field corn and of 10 varieties of ensilage corn were obtained. A test was also made of 10 common varieties of oats to determine which was the most productive, the most rust proof and best adapted to New Hampshire conditions. These varieties varied in yield from 40 to 68 bushels per acre and from 29 to 34.5 lbs. per bushel, one known as Long's White Tartar proving the best all-round variety.

A three-quarter acre plot of winter wheat yielded at the rate of 30.75 bushels of grain and 2580 lbs. of straw per acre. This grain was sold at the rate of $1.25 to $1.50 per bushel. On the wheat ground grass seed was sown the latter part of March, and a most excellent catch was secured, thus showing a new method of seeding down for New Hampshire conditions. Spring wheat yielded at the rate of 18.2 bushels of grain and 3010 lbs. of straw per acre.

During the present season the yields and maturity of 29 varieties of field corn and of 12 varieties of ensilage corn have been determined, but are being reserved for a separate publication on Corn Culture. Twelve varieties of oats, two of wheat

and five of barley were tested this year, the results of which will be published later.

4. Fertilization of Grass Land.

Certain tests begun in 1907 and planned to continue until 1912, or later, are being conducted on a heavy clay soil with a series of 47 plots, 30 of which are 1-10 acre and 17 are 1-20 acre. Each plot has been plowed as a separate land, and a 3-inch tile drain has been placed between every other one of them. The plots thus have equal surface and underdrainage, which is very essential for uniform results.

The objects of this experiment are, first, to secure data upon the yields of hay from continuous growth upon unfertilized land; second, to determine what fertilizer constituent is most needed in the given type of soil; third, to determine in what form any given constituent can be most economically applied; fourth, to determine the amounts of any constituent, or constituents, which will produce the largest yields; fifth, to determine the effect of lime alone, and in conjunction with various combinations of fertilizers; sixth, to afford an opportunity to study the question of the "availability of potash." The last two are matters of chemical concern and are being investigated by the chemical department.

The scheme of fertilization is as follows:

Table I. *Plan of Grass Fertilizer Plots, 1907 to 1912.*

Plot.	Amt. per acre.	Kind of Fertilizer.	Plant food added per acre.
1.	200 lbs.	Nitrate of Soda,	30 lbs. Nitrogen.
2.	....	Nothing,	......
3.	150 lbs.	Sulfate of Ammonia,	30 lbs. Nitrogen.
4.	175 lbs.	Tankage,	13 lbs. Nitrogen. 17 lbs. Phis. Acid.
5.	....	Nothing,	......
6.	215 lbs.	Acid Phosphate,	30 lbs. Phos. Acid.
7.	110 lbs.	Rock Phosphate,	30 lbs. Phos. Acid.
8.	....	Nothing,	......
9.	175 lbs.	Thomas Slag,	30 lbs. Phos. Acid.
10.	110 lbs.	Ground Bone,	27 lbs. Phos. Acid. 3 lbs. Nitrogen.
11.	....	Nothing,	......
12.	60 lbs.	Muriate of Potash,	30 lbs. Potash.
13.	62 lbs.	Sulfate of Potash,	30 lbs. Potash.
14.	....	Nothing,	......
15.	450 lbs.	Wood Ashes,	23 lbs. Potash. 7 lbs. Phos. Acid. 135 lbs. Lime.
16.	300 lbs.	Land Plaster,	75 lbs. Lime.
17.	....	Nothing,	......

Plot.	Amt. per acre.	Kind of Fertilizer.	Plant food added per acre.
18.	10,000 lbs.	Manure,	40 lbs. Nitrogen. 25 lbs. Phos. Acid. 40 lbs. Potash.
19.	100 lbs. 108 lbs.	Nitrate of Soda, Acid Phosphate,	15 lbs. Nitrogen. 15 lbs. Phos. Acid.
20.	....	Nothing,	......
21.	100 lbs. 30 lbs.	Nitrate of Soda, Muriate of Potash,	15 lbs. Nitrogen. 15 lbs. Potash.

Table I. *Plan of Grass Fertilizer (Continued.)*

22.	108 lbs. 30 lbs.	Acid Phosphate, Muriate of Potash,	15 lbs. Phos. Acid. 15 lbs. Potash.
23.	....	Nothing,	......
24.	67 lbs. 72 lbs. 20 lbs.	Nitrate of Soda, Acid Phosphate, Muriate of Potash,	10 lbs. Nitrogen. 10 lbs. Phos. Acid. 10 lbs. Potash.
25.	400 lbs.	Nitrate of Soda,	60 lbs. Nitrogen.
26.	....	Nothing,	......
27.	300 lbs.	Sulfate of Ammonia,	60 lbs. Nitrogen.
28.	350 lbs.	Tankage,	26 lbs. Nitrogen. 34 Phos. Acid.
29.	....	Nothing,	......
30.	430 lbs.	Acid Phosphate,	60 lbs. Phos. Acid.
31.	220 lbs.	Rock Phosphate,	60 lbs. Phos. Acid.
32.	....	Nothing,	......
33.	350 lbs.	Thomas Slag,	60 lbs. Phos. Acid.
34.	220 lbs.	Ground Bone,	54 lbs. Phos. Acid. 6 lbs. Nitrogen.
35.	....	Nothing,	......
36.	120 lbs.	Muriate of Potash,	60 lbs. Potash.
37.	125 lbs.	Sulfate of Potash,	60 lbs. Potash.
38.	....	Nothing,	......
39.	900 lbs.	Wood Ashes,	46 lbs. Potash. 14 lbs. Phos. Acid. 270 lbs. Lime.
40.	20,000 lbs.	Manure,	80 lbs. Nitrogen. 50 lbs. Phos. Acid. 80 lbs. Potash.
41.	....	Nothing,	......
42.	200 lbs. 215 lbs.	Nitrate of Soda, Acid Phosphate,	30 lbs. Nitrogen. 30 lbs. Phos. Acid.
43.	200 lbs. 60 lbs.	Nitrate of Soda, Muriate of Potash,	30 lbs. Nitrogen. 30 lbs. Potash.
44.	....	Nothing,	......
45.	215 lbs. 60 lbs.	Acid Phosphate, Muriate of Potash,	30 lbs. Phos. Acid. 30 lbs. Potash.
46.	135 lbs. 145 lbs. 40 lbs.	Nitrate of Soda, Acid Phosphate, Muriate of Potash,	20 lbs. Nitrogen. 20 lbs. Phos. Acid. 20 lbs. Potash.
47.	....	Nothing,	......

Size of Plots 1 to 30, 1-10 acre; 31 to 47, 1-20 acre.

Each plot will be fertilized exactly the same every year, and every third plot, in order to serve as a check on the others, will receive no fertilizer of any kind during the entire period. Since it is planned to have the series continue for a period of five to ten years, no definite results can be given at this time. It may be stated in general terms, however, that the nitrogen fertilizers are giving the best returns, with timothy and red top predominating, while the phosphoric acid and manure are encouraging the growth of the clovers.

5. Fertilizing Old Sod Land.

In the spring of 1904 an acre plot of a four-year-old sod on uniform sandy loam soil was divided into four equal sections. On April 20th section 1 received a mixture of 150 lbs. nitrate of soda, 100 lbs. acid phosphate and 50 lbs. muriate of potash at the rate of 300 lbs, per acre; section 2 received nothing; section 3 received nitrate of soda at rate of 300 lbs. per acre; section 4 received barnyard manure at rate of 12 tons per acre.

On April 21st, 1905, the same kinds and amounts of fertilizer were applied to the sections as in 1904. In 1906 no fertilizer or manure of any kind was applied, the object being to see how persistent the effect of the two previous applications would be. The results are given in the following table, where the nitrate of soda is figured at $56, the acid phosphate at $14, the muriate of potash at $42, the manure at $1, and the hay at $14 per ton:

Table 2. *Showing Effect and Value of Fertilizers on Old Sod.*

	Complete Fert. Ton per A.	Nothing Tons per A.	Nitrate of Soda Tons per A.	Barnyard Manure Tons per A.
Yield 1904	2.76	2.28	2.36	2.98
Yield 1905	2.70	1.73	2.39	3.01
Yield 1906	1.90	1.71	1.65	2.64
Total	7.36	5.72	6.40	8.63
Increased yield	1.64	0.00	.68	2.91
Value of increase	$22.96	0.00	$9.52	$40.74
Value of fert.	11.90	0.00	16.80	24.00
Profit or loss	+ 11.06	0.00	—7.28	+16.74

The following conclusions may be drawn from the results in the table:

1. That a complete chemical fertilizer gives a very fair return but is not persistent.
2. That nitrate of soda alone was used at a loss; a lighter application would probably have been more economical.

3. That barnyard manure makes a good top-dressing for grass land, and that its effect is persistent.
4. That sod lands of medium age can be greatly benefited by proper kinds of top-dressings.

6. Forage Crops.

The principal work during the past two years in this line has been with alfalfa. Many inquires from farmers in all parts of the state have been received concerning it, and so much interest has been shown that continued study of the plant seems warranted. Our experience with alfalfa here is contained in Press Circular No. 1, published elsewhere in this report. During the past season co-operative tests on 1-4 to 1-2 acre plots have been conducted with farmers in various parts of the state. About three-fourths of these have reported good stands this fall, while the remaining one-fourth have had trouble with weeds, dry weather and ledgy soil. The two critical points in securing a stand seem to be in having a soil which is free from weeds, and one which will not heave with freezing.

A second important forage crop, especially for those engaged in sheep raising, is Dwarf Essex rape. This is a plant belonging to the Mustard family and is not unlike kale or headless cabbage, to which it is closely related. It is a plant of European origin, and is just being generally introduced into this country, as its merits are being found out. It may be sown any time between May 1st and July 1st, and will produce from five to six tons per acre of a very palatable, green forage. It may be sown either in drills or broadcast, about 2 1-2 lbs. of seed per acre being used in the former and 4 lbs. in the latter case. If the ground is free from weeds, broadcasting is preferable, but if it is inclined to be weedy sow in drills 30 inches apart and cultivate. The plants are not easily injured by frost, and when successive sowings are made, continuous pasturage may be had from the middle of July to the first of November.

7. Seed Testing.

On account of the high percentage of weed seed, dead seed, and other foreign matter which we have found in commercial grass seed during the past few years, a press circular was published in January of this year, requesting all those who desired to have samples of grass seed inspected, to send them to the Station, where such inspection would be made free of charge. Thirty samples were received and reported on to the parties interested. The following table shows in a summarized way the results of the inspection:

Legend to Columns

I. Sample number.
II. Name and address of senders, and the kind and the number of weed seeds found in one pound of the seed.
III. Percent of vitality.
IV. Percent of purity.
V. Percent of foreign seed.
VI. Percent of dirt or inert matter.
VII. Number of seeds in one pound of the sample.
VIII. Number of immature or ungerminable seeds in pound of the sample.

Table 3. *Seed Inspection, 1908.*

I	II	III	IV	V	VI	VII	VIII
	TIMOTHY						
6.	C. L. Jenness, Dover................ Red Clover 225; Goosefoot 225.......	97.20	99.79	0.21	0.0	966,384	27,059
12.	Holbrook Groc. Co., Keene	96.0	99.81	0.0	.19	1,132,176	45,287
16.	C. L. Jenness, Dover................	91.5	99.1	0.0	.90	1,097,266	88,516
20.	Hilliard & Kimball, Exeter......... Blue Vervain 1134; Evening......... Primrose 1134; Alsike Clover 21,268.	93.5	99.1	0.9	0.0	1,170,132	76,058
24.	Breck & Sons, Boston..............	95.0	99.94	0.0	0.06	1,187,748	59,387
28.	C. N. Dodge, Hampton Falls........ Rugel's Plantain 907; Alsike Clover 454; Sheep Sorrel 227; Ribgrass 227; Crabgrass 227..	95.0	99.41	0.29	0.3	931,660	46,583
30.	Holbrook Groc. Co., Keene........ Red Clover 226; Crabgrass 226.......	94.0	99.78	0.12	0.1	1,092,643	65,558
	RED TOP						
3.	Holbrook Groc. Co., Keene Timothy 15,880......	66.0	98.56	0.98	0.46	4,643,300	1,578,715
5.	C. L. Jenness, Dover..... .... Timothy 235,934......................	67.0	85.7	14.3	0.0	4,240.372	1,399,422
18.	C. L. Jenness, Dover................ Timothy 185,118............	72.7	87.0	12.0	1.0	5,260,520	1,433,492
23.	Breck & Sons, Boston............... Timothy 181,388; Rugel's Plantain.. 3629	79.0	77.04	15.52	7.44	3,936,832	826,735
29.	C. N. Dodge, Hampton Falls........	59.0	99.5	0.0	0.5	4,916,440	2,015,740
	RED CLOVER						
2.	Holbrook Groc. Co., Keene......... Timothy 544; Ribgrass 363...........	88.0	98.83	0.63	0.54	278,441	33,413
7.	Geo. H. Brown, Manchester......... Timothy 8166; Green Foxtail 1633;... Ribgrass 998; Bitten Dock 817; Sheep Sorrel 363...........................	85.0	95.34	2.86	1.8	311.032	46,655
8.	Geo. H. Brown, Manchester......... Timothy 1361; Green Foxtail........ 816; Sheep Sorrel 363; Bitter Dock.. 272; Pigweed 272....	83.0	97.34	2.29	.37	293.808	49,947
11.	Geo. H. Brown, Manchester......... Sheep Sorrel 3640; Ribgrass 420......	91.0	99.15	0.85	0.0	259.156	23,324
13.	Holbrook Groc Co., Keene..........	91.0	99.85	0.0	0.15	299,044	26,913
15.	C. L. Jenness, Dover, Ribgrass...... 3539; Worm Seed 1361; Sheep Sorrel 725; Green Foxtail 726; Hoarhound 272....	78.7	93.91	4.85	1.24	349,216	74,383
19.	Hilliard & Kimball, Exeter, White Dock 19,872; Ribwort 6261, Sheep.... Sorrel 1543; Mexican Tea 1270; Green Foxtail 726; Canada Thistle 635;..... Wormseed 364, etc..................	72.5	79.65	19.32	1.03	295,532	81,271
22.	Breck & Sons, Boston, Ribgrass..... 4265; Green Foxtail 635; Goosefoot.. 1906; Sheep Sorrel 998; Timothy 726.	78.25	95.72	3.09	1.19	364,312	79,237
26.	C. N. Dodge, Hampton Falls Ribgrass 363; Green Foxtail 181; Unknown 1815..............	82.5	97.62	0.83	1.55	285,356	49,937

TABLE 3. *Seed Inspection, 1908 (Continued).*

I	II	III	IV	V	VI	VII	VIII
	ALSIKE CLOVER						
1.	Holbrook Groc. Co., Keene......... Timothy 36,751; Sheep Sorrel 907....	75.0	95.45	4.33	0.12	843,340	210,835
10.	Geo. H. Brown, Manchester......... Timothy 454........................	92.0	99.93	0.07	0.1	711,716	56,937
17.	C. L. Jenness, Dover, Timothy...... 14,155; Sheep Sorrel 362; Crabgrass 181; Unknown 272...................	84.0	96.0	3.75	0.25	705,356	112,856
25.	Breck & Sons, Boston, Timothy..... 119,328; Sheep Sorrel 4310; Evening Primrose 680; Green Foxtail 227;.... Peppergrass 227.....................	86.25	90.6	9.4	0.0	783,288	107,702
27.	C. N. Dodge, Hampton Falls......... Timothy 17,014; Canada Thistle 227; Lamb's Quarters 227.................	89.5	98.18	1.82	0.0	663,816	69,700
	ALFALFA						
4.	H. T. Corey, Manchester............	92	98.9	0.48	0.62	258,325	20.346
9.	Geo. H. Brown, Manchester......... Ribgrass 1814; Golden Hawkweed... 182..................................	79.5	99.16	0.74	0.10	254,324	52,136
21.	Breck & Sons, Boston, Ribgrass 272; Unknown 453.......................	98.5	99.24	0.28	0.48	226.860	3,403

8. CO-OPERATIVE WORK.

During the past season three lines of co-operative work have been carried on by this department in various parts of the state. These are as follows:

1. The growing of alfalfa.
2. The growing of ensilage corn.
3. Fertilizer tests with corn.

In the tests with alfalfa the station furnished the necessary seed for 1-4 to 1-2 acre plots, and gave directions and suggestions for preparing the ground and sowing the seed. Twenty-five farmers co-operated in the work this season.

Two farmers in the vicinity of Whitefield co-operated in the growing of ensilage corn for the purpose of finding the comparative maturity and adaptation of different varieties in the northern part of the state. In this case the Station outlined the test and furnished the seed.

A co-operative test with fertilizers on tenth acre plots of pop-corn, was conducted at East Wakefield. The purpose being to determine the fertilizer needs of the ridge soils in that vicinity. The Station furnished and mixed the fertilizers and supervised the planting and handling of the crop.

III. ANIMAL HUSBANDRY.

The work in Animal Husbandry has been carried on under four heads, namely:

1. Sheep breeding (Early lamb production).
2. Sheep feeding.
3. Pig feeding.
4. Comparison of corn stover and hay for dairy cows.

I. Sheep Breeding.

The sheep breeding work, as outlined in the previous report, was carried on during the season of 1907-08, as follows:

The breeding season opened August 1st and continued until October 26th. The flocks, five in number, were headed respectively by pure bred Hampshire, Shropshire, Dorset Horn, Lincoln and Southdown rams. Each flock consisted of pure bred ewes of the same breed as the ram heading the flock, grade Rambouillet ewes, and native ewes.

The lambs following this breeding season began to come on December 29th, with the pure bred Dorset Horn and Rambouillet ewes lambing earliest.

The average birth weight of lambs sired by the Hampshire ram was 9.5 lbs; of lambs sired by the Shropshire, 7.7 lbs; of lambs sired by the Dorset Horn, 8.4 lbs; of lambs sired by the Lincoln, 8.43 lbs. The Southdown ram proved a non-breeder. The weekly gains made by the lambs sired by these several rams were carefully studied and compared. The heaviest gains were made by lambs sired by the Hampshire and Shropshire rams. The lambs sired by the Dorset Horn ram ranked third as regards gains, and those sired by the Lincoln ram fourth. All of the Hampshire and Shropshire crosses fattened well and also made growth; the Dorset Horn and Lincoln Rambouillet cross did not fatten well; hence they did not make desirable carcasses when dressed. With but one exception the lambs sired by the Lincoln ram did not make good killing lambs.

The early lamb market requires a lamb which is young, short in legs, short and broad in body, well fattened and dresses between 25 and 30 pounds.

The following cuts, with descriptions, show the desirable types and undesirable types in early lambs; also the characteristics of lambs of the crosses above mentioned.

On April 20th five lambs were dressed and shipped to the Boston Market. Total selling price $26.00.

On May 25th thirteen lambs were dressed and shipped to the Boston Market. Total selling price $76.00.

The first consignment of lambs was put on a low market. The second consignment was put onto a better market, and, as a whole, was a better class of lambs.

The demand of the market is for the better lambs; with better lambs a higher price can be obtained. Much depends upon the type of sire used.

Fig. 6. Shropshire-Rambouillet. Ewe Live weight, 52 lbs.; Dressed weight, 26 lbs.; Dressing per cent., 50. Type: Blocky and fat. A very desirable lamb.

The earlier the lambs can be put onto the market the higher the price will be. In order to have early lambs the ewes must be induced to breed as early as August, at least. This can be accomplished by taking the lambs from the ewes early and allowing them to recuperate on rich, succulent pasture before the ram is let to them. The best succulent pasture that can be sown for ewes is rape. It will have a tendency to increase the

condition of the ewes quickly and fit them for ram service early.

II. Sheep Feeding.

On March 25th 8 yearling ewes and 8 aged ewes were divided into two lots, 4 yearlings and 4 aged ewes in a lot, for the purpose of comparing Xtravim Molasses with corn meal, as a fattening feed for sheep.

Fig. 7. Shropshire-Native. Ram. Live weight, 60 lbs.; Dressed weight, 28 lbs.; Dressing per cent., 46.6. Type: Blocky, not so fat as 1.

Lot I was fed molasses, middlings and oats in the following proportions for concentrated feed: Molasses 1-2, Middlings 1-4, Oats 1-4. Their roughage was second crop clover.

Lot II was fed corn meal, middlings and oats in the following proportions, as a concentrated feed: Corn meal 1-2, middlings 1-4, oats 1-4. Their roughage was second crop clover.

Lot I received 1.13 lbs. of the molasses and grain mixture and 1.52 lbs. hay per head, per day.

Lot II received 1.17 lbs. of the grain mixture and 1.52 lbs. hay per head per day.

The preliminary feeding period was from March 25th to April 1st. The feeding period was 60 days in length, lasting from April 1st to May 31st.

The gain of Lot I was 1.4 times that of Lot II, and was made 1.5 times cheaper for each 100 lbs. gain.

III. Pig Feeding.

On October 5th 15 shoats, averaging in weight from 141 to 151 lbs., were divided into five lots, three in a lot, for fattening.

Fig. 8. Hampshire-Rambouillet. Ram. Live weight, 62 lbs.; Dressed weight, 30 lbs.; Dressing per cent., 48. Type: Blocky, low and thick; fast growing and easy fattening.

These lots were fed 7 days as a preliminary feeding period, on the feeds used in the experiment. On October 11 and 12th they were again weighed, an average taken and these weights used as initial weights. The feeding period extended from Oct. 12 to Nov. 16th, a period of 35 days, with the following results:

At the end of the feeding period all of these lots were in good market condition, Lot I being the least desirable.

Lot I, fed soaked shell corn, gained 87.2 lbs. at a cost of 7.3c. per pound.

Lot II, fed shelled corn and skim milk, gained 141 lbs. at a cost of 7.4c. per pound.

Lot III, fed shelled corn and middlings, gained 99.3 lbs. at a cost of 8.9c. per pound.

Lot IV, fed shelled corn, middlings and skim milk, gained 129 lbs., at a cost of 8.2c. per pound.

FIG. 9. Hampshire-Native. Ram. Live weight, 54 lbs.; Dressed weight, 27 lbs.; Dressing per cent., 50. Type: Broad and deep bodied, but a trifle too long legged.

Lot V, fed shelled corn, middlings and molasses, gained 104.7 lbs., at a cost of 8.89c. per pound.

In the above feeding test none of the gains were satisfactory; too much feed was consumed for the gains returned. The cost of gains were too high in all cases. This can be explained by the fact that the price of grain was high, the hogs were started on feed at an age when the cost of grain is high, and the total gains were too low.

IV. Comparison of Corn Stover and Hay for Dairy Cows.

In view of the fact that several inquiries had been received concerning corn stover in dairy rations, and also that considerable corn stover was left for feed it was deemed wise to feed it to the best advantage to the dairy cattle, and to determine its value from the feeding standpoint.

Fig. 10. Lincoln-Native. Ram. Live weight, 47.5 lbs.; Dressed weight, 24.5 lbs.; Dressing per cent., 51.1. Type: Blocky, low set; broad and fat.

Accordingly, four cows in about the same period of lactation, constituted two lots which were fed as follows:

Lot I consumed 489 lbs. grain, 1125 lbs. corn stover and 1645 silage, from January 20th to February 19th, and produced 1622.3 lbs. milk, testing 3.75 per cent., making 59.76 lbs. butter fat.

Lot II consumed during the same period 489 lbs. grain, 1240 lbs. cut corn stover and 1645 lbs. silage, and produced 1221.1 lbs. milk, testing 4 per cent., and making 48.84 lbs. butter fat.

On Feb. 20th the feeding of corn stover and hay was reversed from Lot II to Lot I, Lot II receiving hay and Lot I receiving corn stover.

The period from February 20 to March 1 was used to get the cows well started. The second feeding period started on March 1st and extended to March 30th.

FIG. 11. Lincoln-Rambouillet. Ewe. Live weight, 56.5 lbs.; Dressed weight, 25 lbs.; Dressing per cent., 44. Type: Long and hard to fatten.

Lot I consumed 517.5 lbs. grain, 1057 lbs. corn stover and 1860 lbs. silage, and produced 1345.8 lbs. milk testing 3.65 per cent., and making 50.17 lbs. butter fat.

Lot II consumed 508 lbs. grain, 1222 lbs. hay and 1860 lbs. silage, and produced 1269.4 lbs. milk testing 3.9 per cent., and making 49.42 lbs. butter fat.

2297 lbs. corn stover, in conjunction with 3505 lbs. silage and 1006.5 lbs. grain, yielded 2566.1 lbs. milk and 99.01 lbs. butter fat.

2347 lbs. hay, in conjunction with 3505 lbs. silage and 1006.5 lbs. grain yielded 2891.7 lbs. milk and 109.18 lbs. butter fat.

The hay fed was straight Timothy. The cows in Lot I, when put onto corn stover, lost flesh. The cows in Lot II, when put onto timothy hay, gained flesh.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

W. H. Pew, Animal Husbandman.

On July 1st, 1908, the Animal Husbandry Department was made a separate department. The work of this department has been planned as follows:

1. Sheep Breeding. (New Project.)
2. Sheep Feeding.
3. Pig Feeding.

I. Sheep Breeding. (New Project.)

The sheep breeding work during the year past was carried on under the Hatch Fund. On April 1st new work was outlined under the Adams Fund, as follows:

A. Objects.

1. To determine the principles involved and best methods to be employed in grading up a flock of sheep, particularly for early lamb production, studying the characters of crosses with reference to Mendel's law.

2. To determine the priciples involved in fixing certain characters in sheep, studying the closeness with which the characters of the hybrids follow Mendel's law, and their application to breeding problems.

B. Plan.

1. Plan of object. (1)

a. Breed a pure-bred Dorset Horn ram to Grade ewes of uniform type; select from this cross representative males and females; breed these together to produce some characters which are pure; choose the most desirable character and perpetuate it by the use of successive generations of these crosses, as breeding stock, studying the characters of the generations to determine how closely they follow Mendel's law.

The Dorset Horn ram will be used in this line of breeding because the Dorset Horn breed combines early breeding and heavy milking qualities.

2. Plan of object (2).

a. Breed a pure-bred Hampshire ram to pure bred Rambouillet ewes; using this cross because of the color markings and form of the Hampshire, and the fleece of the Rambouillet. In succeeding matings use the progeny of this cross; study the hybrid characters; how closely

FIG. 12. Dorset-Rambouillet. Ram. Live weight, 56 lbs.; Dressed weight, 21 lbs.; Dressing per cent., 37.5. Type: Lacked flesh and thickness; very heavy paunch. Very poor dressing type of lamb.

they follow Mendel's law and how they may be applied to breeding problems.

b. Make reciprocal crosses with the Dorset Horn and Southdown breeds using: 1st, the Southdown ram on Dorset Horn ewes, and 2d the Dorset Horn ram on Southdown ewes. Study closely the Mendalian characters shown by these crosses and their value to practical breeding problems.

These reciprocal crosses will be made to determine the influence of the male and female of each breed.

c. Study the fecundity of strains of breeds of sheep, and perpetuate this quality by crossing with multi-nippled sheep. The fecundity of Dorset Horn Sheep will be studied with reference to the flock records and information gathered from breeders. No breeding will be done for one year, but data will be gathered.

Inasmuch as the Lincoln crosses did not prove out successfully for early lamb types, it has been thought best to discard these crosses and breed up a small flock of pure bred Lincolns, adapted to New Hampshire conditions. These pure breds will be utilized in the future in breeding for wool characteristics.

Co-operation in this work has been arranged with the Department of Experimental evolution of the Carnegie Institute, Cold Spring Harbor, N. Y., whereby the Director of this Department makes two trips a year to the New Hampshire Experiment Station and inspects the work as previously outlined, offering suggestions as the work progresses. This will be of great value to the experiment, as a large amount of experimental work on breeding questions has been done at the Carnegie Institute.

Thus far the work has been carried on as outlined.

The lambs were taken from the ewes early so that they were given a chance to recuperate. On July 15th the entire flock of ewes were put onto a piece of well grown rape and kept there until August 1st. About July 25th, 2 pure bred Hampshire ewes, 2 pure bred Shropshire ewes, 3 pure bred Dorset ewes, and 4 pure bred Rambouillet ewes were added to the breeding flock. A yearling Southdown ram and yearling Hampshire ram, both of grand type, were purchased to head their respective flocks.

The breeding season opened on August 1st. A number of ewes were bred the first week in August. During the month between thirty-five and forty ewes were bred. The earliness of breeding is due to the increase in condition of the ewes pasturing on the green, succulent rape.

Before another grazing season opens, more pasture land must be provided for the sheep; a shortage of pasture has been a great handicap to the work this year, as the pasture land allotted to the sheep work is insufficient on account of lack of acreage, as well as productiveness. The rape sown for the sheep proved of great value during July and August, but was insufficient to carry through the fall months.

II. Sheep Feeding.

A continuation of the sheep feeding work, carried on last spring, will be made next spring. A further study of molasses in the sheep ration will be made. The number of sheep that will be available cannot be determined at this time.

III. Pig Feeding.

There are a number of problems confronting the hog grower from the feeding standpoint, the greatest of which is the growing of hogs with profit without depending upon waste products. Green forage crops for growing pigs is attracting attention. The feeding of packing house by-products is becoming more prominent. In order to do satisfactory experimental work along this line proper equipment in the way of a piggery must be provided.

REPORT OF THE DEPARTMENT OF BOTANY.

CHARLES BROOKS.

ORGANIZATION AND EQUIPMENT.

Since July 1, 1908, Mr. Isaac M. Lewis has served as assistant in botany. He has made the leaf spot of apples a subject of special investigation and gives his results and conclusions under that head in this report.

The great need of the department is a small greenhouse in which plants may be reared, and where inoculation experiments may be carried on under known conditions. Because of the lack of this, it has often been necesasry to leave the relation of a fungus to its host undetermined and the most important problems in connection with certain diseases unsolved.

INVESTIGATIONS.

The Physiology of the Baldwin Apple Tree. One of the problems undertaken under the Adams Fund was a study of the physiology of the Baldwin tree with special reference to the determination of the factors controlling the formation of fruit buds. Such literature as bears upon the subject has been reviewed, buds gathered at various seasons of the year have been studied, experiments in artificial nutrition made, and experiments carried out to determine the effect of overbearing. The work is not near enough completion to justify a full report.

Fruit Spot of Apples. A second line of work under the Adams Fund is the determination of the cause, nature and prevention of certain little understood diseases. The first problem taken up was the Fruit Spot of apples. The work has been brought practically to completion. The results and conclusions are given on pages 332-365.

Leaf Spot of Apples. A second disease investigated under the same fund was the Leaf Spot of Apples. A preliminary report on this is given on pages 365-370.

Pine Blight. Considerable time has been given to an investigation of this much talked of trouble. The information is reported and discussed on pages 370-371.

Fungous Diseases of the State. An important line of work under the Hatch Fund, has been a study of the diseases of plants as they occur in the state. Much of the correspondence of the department has been in answer to inquiries as to the identity and prevention of these diseases. A record has been kept of the extent and nature of these troubles, and a partial report is given on pages 371-382.

Fungicides. Experiments have been made to determine the value of various proprietary fungicides that are now upon the market, and in search of a fungicide that has the efficiency of bordeaux but is less likely to russet the fruit. See pages 382-385.

Government Cooperative Work. A part of the work on fungicides has been carried on in co-operation with the Bureau of Plant Industry, U. S. Department of Agriculture. See pages 385-389.

Apple Diseases. Extensive experiments have been made in the control of apple diseases. The results are quite conclusive. See pages 332-370 and 382-389.

Potato Diseases. In the summer of 1907 various fungicides and several methods of spraying were tested on potatoes. There was no late blight that season and the early blight was not very serious. The foliage on the sprayed potatoes was green until frost, while that on the unsprayed ones was practically dead ten days before that time. The potatoes used in the experiments were planted late and the sprayed plants were killed before maturity by the frosts of September 18. The yields obtained showed decided advantage from spraying. The results did not make it conclusive as to the comparative value of the various fungicides, and can be discussed better after further tests have been made.

Cucumber Diseases. In view of the widespread destruction of the cucumbers by blight in 1906, experiments were planned the

next season to determine the best fungicides for the control of the disease and the best method of application. No blight occurred that summer and no benefit was seen from spraying.

Weeds and Their Destruction. The large number of inquiries in regard to the identity of weeds and as to the best means of destruction, made special demand for definite data upon the use of chemicals for their control. The work on this problem is reported on page 389.

*THE FRUIT SPOT OF APPLES.

CHARLES BROOKS.

(WITH PLATES 1-7)

A considerable percentage of the Baldwin apples of New England are marred by the presence of certain fruit spots, described in the Bulletins of the New Hampshire Experiment Station as the Brown Spot of Baldwins. The following paper is a report of the results obtained in an effort to determine the cause of this spot, its morphological and physiological characteristics, and means of prevention. A brief review of earlier work on this and closely related effects will be of value in the later presentation of the subject matter.

REVIEW OF LITERATURE.

In 1879 Sorauer (1) described a disease which he called the "Stippichwerden der Aepfel." According to his description, brown or blackish brown spots developed on the surface of the fruit, extending into the flesh only .5 to 1.5 mm. These spots remained isolated and never involved the whole fruit. He found that they might remain without development for a long time and later develop rapidly in storage. He considered the spots to be due to a decomposition produced by a particular fungus and gave *Spilocaea Pomi*, previously described by Fries (2), as the probable agency.

Reichelt (3) reported a similar spot on apples but found that it was caused by a fungus belonging to the genus *Synchytrium*.

Frank (4) thought that the *Spilocaea Pomi* of Fries was a sterile form of *Fusicladium dendriticum*, thus making the "Stippen der Aepfel" identical with scab.

Wortmann (5) made extensive studies of the "Stippen der Aepfel." He described the disease as producing numerous brown spots on the surface of the fruit. At first these were but 1 to 5

---

*Offered as a thesis at the University of Missouri in partial fulfillment of the requirements for the degree of doctor of philosophy.

mm. in diameter and entirely separate and distinct, but later they might become larger and more numerous, practically covering the entire surface of the apple. The spots usually developed after the fruit had been gathered and while it was passing through its final ripening processes, but with especially susceptible varieties they sometimes appeared while the apples were still on the tree. The tissue beneath these spots was browned, possessed an over-abundance of starch and in late stages was bitter to the taste. He did not consider the disease to be of fungous origin, not only because he was unable to find any trace of mycelium in the affected tissue but also from the fact that the spots were often covered by a smooth and unbroken epidermis and might be found at a depth of one centimeter from the surface and entirely separated from all other affected tissue. He believed that the disease was a physiological one and that conditions of transpiration were largely responsible for its occurrence. He found that varieties of apples that were susceptible to spotting had more lenticels and a thinner-walled epidermis than those less affected by the disease. On the other hand, these same susceptible varieties gave off less water in transpiration than the more resistant ones. From these observations and from the previously known fact that spotting might be prevented by a rapid drying of the fruit, he drew the conclusion that the extent of the disease was not determined by the actual amount of transpiration but by the readiness with which water was conducted from deeply seated cells to replace that lost in transpiration. The varieties that had the slowest rate of conduction were the ones that were most seriously affected. The concentration of the cell sap in the exposed tissue was the real cause of the injury and the acids and acid salts were the active agents in killing the cells. As an explanation of the fact that apples do not become spotted when dried very rapidly, he suggested that under such conditions the acid did not have time to act. He believed that the nature of the substances in the cell sap partially accounted for the differences in the susceptibility of different varieties.

Zschokke (6) presented a detailed report in regard to the structure of the epidermis in core-fruits with special reference to the part it plays in determining their keeping quality. His description of the "Stippen," and his conclusions in regard to it are almost identical with those of Wortmann.

In Australia a disease supposed to be identical with the "Stippen" is described by Cobb (7) as Brown or Bitter Pit.

Craig (8) described a similar disease occurring in Canada as the Dry Rot of the apple. He found that sixty different varieties of apples were susceptible, but that the Baldwins were affected most seriously.

In the United States the spotting of apples has been repeatedly described and variously named. Selby (9) reported a disease of Northern Spies and other varieties which produced small brown spots just beneath the skin of the apple and which usually did not extend to any great depth into the tissue. He found no fungus present and considered it a breaking down of cells brought about by seasonal conditions.

Jones (10) described the "Brown Spot of the Baldwin Apple" as producing brown sunken spots the size of a pea or larger on the surface of the apple. The flesh underneath these spots showed a brown discoloration for an eighth of an inch or more in depth. The discolored portion was quite bitter to the taste. Specimens of the diseased fruit placed in a moist chamber soon developed small grayish pustules at or near the center of the spot, the pustule being from a sixteenth to an eighth of an inch in diameter. Specimens of the fungus were sent to J. B. Ellis for identification who reported that it was probably *Dothidea pomigena* Schw. Later, Jones (11) stated that the fungus occurring in the spots was quite different from the above species. In most cases, especially in the autumn and early winter, no fungus was detected in the browned tissue. When it was present it was quite obscure. The fungus was not identified because of inability to secure satisfactory fruiting specimens. He considered the fungus a saprophyte and of minor importance so far as the disease was concerned. In the latter publication the spotting was given the following description:

"The disease usually appears superficially on the fruit as small sunken brown spots scattered over the surface of the apple, but more abundantly near the eye or apical portion. These spots may appear before maturity, but usually are seen only after the apples have lain in storage for some time, and tend thereafter to increase in number and size. The spots usually vary in diameter from two to five millimeters. The superficial spots usually lie immediately underneath the epidermis, which in the earlier stage of their development is unbroken. Upon cutting into such a spot it is found to consist of rather dry, dead and browned tissue, extending into the flesh for a distance about equal to its diameter. Similar areas of dead and brown tissue may occur scattered at various depths in the flesh nearly to the core. Examination shows the spots

to be associated in their distribution with the occurrence of the vascular bundles of the fruit. The browned tissue may have a slightly bitter flavor in the older spots, but this bitterness is not constant and in no case in our observation is it very decided."

He found that while the spotting was worse on Baldwins than on any other variety it was quite common on Northern Spies and occurred on Greenings.

Stewart's (12) description of the "Baldwin Spot" is quite similar to that given by Jones. He did not detect the bitter taste that Jones had found the browned tissue to have. The smallest spots might show no brown color at all but he indicated merely by a deeper red color of the skin if situated upon the colored part of the fruit, or by a green color if situated upon the lighter portion. At the time the fruit was gathered the spongy tissue was found only underneath the surface spots, but after it had lain some three weeks in the laboratory many brown spots were found distributed irregularly through the flesh of the calyx half of the fruit, but not in the stem half. Apples placed in moist chambers showed no development of any fungus and pieces of browned tissue transferred to various culture media gave no growth. No beneficial results from spraying had been observed. In a later bulletin (13), an orchard was reported in which the disease had been almost entirely prevented by spraying. The most susceptible varieties were Baldwin, Northern Spy, and Rhode Island Greening.

Clinton (14) described the "Baldwin Spot" as showing first in the fall as small sunken rotten spots on the surface of the fruit and later as isolated brown spots within the flesh, the tissue in these often collapsing.

In a later report (15) he described another disease of the apple which he called the "Fruit Speck." This disease showed superficially as small spots or specks scattered over the skin. These areas of brownish dead tissue usually varied from the size of a pinhead to a quarter of an inch in diameter and extended but slightly into the flesh. He could frequently see small ruptures at the center of the specks. Diseased tissue when placed in sterile culture media developed a fungous growth. The fungus in the various cultures was apparently the same. Talman Sweets were most seriously affected, Northern Spies suffered less, while Baldwins were injured but little.

Longyear (11) reported a disease common on Baldwins and other varieties in Michigan which he called the "Fruit Spot" of apples. He described it as appearing in the form of small, cir-

cular, slightly sunken spots of a brown color. The brown discoloration usually extended but a little way into the flesh of the fruit and the affected part possessed a bitter taste. The spots gave rise to spore-producing pustules. *Phyllachora pomigena* (Schw.) was credited as the cause of the trouble. Spraying as for scab was found greatly to reduce the disease.

Lamson (17) has published a number of reports on the "Brown Spot of Baldwins" as it occurs in New Hampshire. He gave the following description of the disease: "It is characterized by the appearance on the surface of the apple of numerous small brown spots, varying in diameter from a sixteenth to an eighth of an inch. The spots are slightly sunken or depressed so that the surface has a pitted appearance. They suggest the beginning of rot but do not increase in size ordinarily, though occasionally they do. The disease appears late in the season. The chief injury is to the appearance of the fruit. This is often so much damaged that otherwise perfect apples become seconds." He found that fungicides practically controlled the disease.

For the past two years the writer has been making a study of the spotting of New Hampshire apples. The results obtained are given under the various headings that follow. A knowledge of the host is necessary to an understanding of a disease.

THE STRUCTURE AND DEVELOPMENT OF THE APPLE.

Epidermal structure.—The epidermis of the apple consists of a single layer of cells, the outer walls of which are strongly thickened. These outer walls consist largely of cutin, which as the apple matures is impregnated and covered with a resinous and waxy substance. The apple is thus furnished with a covering that at most points is practically impervious to water and fungi. Many unicellular hairs are found on the surface of the young fruit. The somewhat conical bases of these are inserted between the other epidermal cells. These hairs disappear when the apple is a few weeks old, but before this time the cuticle of the apple has considerable thickness. Zschokke (6) found that in dropping from the apple the hairs might break even with the outer edge of the cuticle, leaving their conical bases behind, but that more frequently they loosened themselves from the surrounding epidermal cells, leaving a deep scar, which, in the latter development of the fruit, might become a definite break in the epidermis. The writer's observations agree with those of Zschokke. As late as the first of August these hair pits were quite common in the epidermis.

In the young fruit the stomata furnish such openings in the epidermis as are necessary for the passage of gases and liquids. They are very numerous early in the year and while the majority of them disappear later they are still quite common on the mature fruit. From three to four weeks after the fall of the blossoms numerous cork-like flecks begin to appear on the apple surface. The majority of these are lenticels (Plate 4, Figure 4.) When the epidermis of the young apple is broken either through a natural or foreign agency, the opening is rapidly covered with cork cells. According to Zschokke (6) the lenticels develop as a result of breaks in the epidermis caused by the rapid enlargement of the apple, the stomata being the points that yield most readily to the strain. In a typical lenticel the cells are arranged in definite layers. In the apple the structure of these corky specks varies all the way from that of a typical lenticel to a few thick-walled cork cells promiscuously arranged beneath a minute break in the cuticle. Their early structure leads the writer to the opinion that while the majority of them develop at stomata others probably originate from the pockets left by the falling hairs.

The lenticels are far more numerous on the blossom half than on the stem half of the apple. This statement is based on actual count as well as on general observations. A square centimeter was marked off on the stem half of an apple and another on the blossom half and the lenticels counted on these areas. By averaging the results secured from the Baldwins the ratio of seven to four was obtained as that existing between the number of lenticels on the blossom and stem halves of the apple. On Northern Spies the ratio was approximately five to three.

Hypodermal parenchyma.—Immediately beneath the epidermis are layers of cells that are distinctly different from those more deeply situated. These cells are smaller and more compactly arranged. They are oblong in shape with their greatest diameter parallel to the epidermis. They are well supplied with chlorophyll and evidently take an active part in the nutrition of the apple. They contain the red coloring-matter of the ripe fruit, which, according to Pick (18), develops from tannin under the influence of sunlight. There is a gradual transition from these cells to the large isodiametric ones that make up the mass of the apple tissue.

Vascular system.—The close relation of the conducting system to spot diseases makes a study of the vascular bundles of interest in this connection. The general distribution of these could be studied best in frozen apples. With these the soft

flesh could be nearly all removed by holding the half of an apple under the current from a laboratory faucet. The remaining portion of the apple could be very satisfactorily studied by floating in water. If an apple is cut in halves perpendicular to the core, ten green spots may be seen arranged in the form of a circle about midway between the core and the epidermis (Plate 3, Figure 1.) These are the large vascular strands of the apple. Smaller branches are given off from either side of them. Figure 7, Plate 7 is a sketch of one of these ten vascular strands with the branches that arise from one side of it *i. e.*, it shows about one-twentieth of the vascular system of an apple. The main branches give off comparatively few smaller ones until near the margin of the hypodermal tissue previously described. Here they branch profusely and anastomose in a seemingly indiscriminate manner. The veinlets from one large vein unite with those from another so that the whole surface system is closely interwoven and connected. In the small veinlets the vascular elements become fewer and fewer, finally giving place to long narrow cells that seem to be transitional between the vascular tissue and that of the apple pulp.

Chemical composition.—The chemical composition of the apple varies greatly with the time of the year.

Pfeiffer (19) reported that crude fiber, ash, protein, sugar, acid, water, pectin, and dextrin all increased in the apple during growth.

Bigelow, Gore and Howard (20) found that the sugar content of winter apples increased from the time of the June drop till November 5, when the apples began to break down and become mealy. During this time the acid, as estimated on a total solids basis, was constantly decreasing. These changes in the sugar and acid content took place very rapidly in the latter half of June and early part of July. The starch content reached its maximum before the last of July and rapidly decreased after that time.

Morse (21) found that the most important change in the apple in the "after-ripening" process was the change of starch to sugar. Cold storage retarded this and other chemical changes but could not prevent them.

Otto (22) reported that when ripe apples were allowed to sweat in piles the starch was entirely converted into sugar in two or three weeks, the fruit thus becoming more valuable for cider-making.

Zschokke (6) reported that the tannin content decreased in the ripening process. He found that the tannin was located largely in the surface cells of the apple. He believed that apples owed their resistance to decay fungi much more to the chemical composition of the cell sap, especially to the tannic and malic acid content, than to any mechanical protection.

THE FRUIT PIT OF APPLES.

The writer finds that there are two distinct fruit spots that occur on New Hampshire apples. Some stages of either of these might be included under any of the previously mentioned descriptions. In the following pages one of these will be called the Fruit Pit and the other the Fruit Spot of the apple.

Characteristics.—In early stages of the Fruit Pit one finds numerous sunken areas from two to six millimeters in diameter on the surface of the apple. These depressions are somewhat hemispherical in shape and have the appearance of bruises. At this stage the spots are not brown and often show no difference in color from the surrounding surface of the apple. They may be a deeper red than the adjacent tissue when occurring on the colored portion of the apple and a darker green when on the lighter parts. Later they begin to take on a brown tint, but at first this seems to show through from rather deeply seated tissue and not to arise from any discoloration of the epidermal or immediately underlying cells. Sections of such spots show that this is the case, and that the browning and the shrinking of the cells occur in the pulp of the fruit and in the tissue that is transitional between it and the hypodermal parenchyma. Later the surface cells also become dark brown. The epidermis may be smooth and apparently unbroken in both early and late stages. As the disease advances spots situated near each other often become confluent, developing into one large spot. In all such cases examined it was found that the original spots were closely connected with one vascular branch.

Internal browning of tissue.—The surface spotting is often accompanied by browning of the tissue immediately surrounding the vascular bundles. Upon cutting such an apple one sees numerous apparently isolated brown spots. Further study shows that these are not isolated but are in reality continuous strands of brown tissue surrounding the vascular bundles. The portion of the vascular system that is most commonly affected is that lying within fifteen millimeters of the surface of the apple (Plate 3, Figure 3). The surface spots often occur without the internal browning and also the internal browning may occur un-

accompanied by any evident surface derangement. The affected tissue in both the surface and vascular regions may have a disagreeable and slightly bitter taste.

Cause and occurrence.—Microscopical examinations of fruit pits have given no indication of the presence of fungi or bacteria. Brown tissue from the surface pits and from the more deeply seated vascular regions has been transferred to various culture media but always without securing bacterial or fungous growth. Both the fruit pit and the internal browning are evidently abnormal physiological conditions. Their nature and location would indicate that they might be the result of some abnormal loss of water from the apple tissue.

The writer's observations give him no reason to conclude that the Fruit Pit is of common occurrence in New Hampshire. In the last three years, with the exception of a few very large Baldwins, he has seen it only as a result of improper storage. Frequent visits to the Boston markets for a study of spotted apples convince him that it is of rare occurrence on the fruit shipped to that city. In January, 1908, he made an unsuccessful search for specimens of Fruit Pit in the markets of Buffalo, Chicago, Toronto, and Montreal. He has recently had the privilege of making a study of the disease on apples from Maine, Michigan, and New York, from Ottawa, Canada, and from Cape Town, Africa. The specimens from all these sources had the characteristics previously given.

THE FRUIT SPOT OF APPLES.

Occurrence and morphology.—This disease is very common in New Hampshire and in the Boston markets one can often find barrels of apples shipped from various sections of New England in which fifty to ninety per cent. of the fruit is spotted. It occurs on almost every variety of apple but is worst on the Baldwins, and the following statements apply especially to the conditions as seen on that variety. The disease appears about the middle of August. At this time one may notice spots of a deeper red on the colored surface of the apple and of a darker green on the lighter portion. They are but slightly sunken if at all and there is no suggestion of a bruise (Plate 1, Figure 1). They usually occur at a lenticel but are sometimes covered with a smooth and apparently unbroken epidermis. The number on the blossom half of the apple is usually from two to ten times as great as that on the stem half. A part of this contrast might be accounted for by the difference in the number of leticels on the two halves of the apple (see page 337), but

must be partly due to some other cause. As the season advances the spots become more prominent (Plate 1, Figure 2). On the red fruit surfaces they become more sunken and their color gradually changes from red to brown or black. At this time they bear a close resemblance to the earliest stages of Black Rot. Sections of the spots show that the hypodermal parenchyma is affected from the first. Only in late stages does the browning and shrinking extend to the large isodiametric cells of the apple tissue. On the green surface the spots may become sunken before harvest time, but the depressions are due to a lack of growth and not to any shrinking of the flesh. A minute black speck usually develops at the lenticel and smaller specks may often be seen at a radial distance of one to three millimeters from the first. A microscopic study of the underlying tissue shows that the cell walls of the hypodermal parenchyma and transitional tissue are abnormally thickened and that this thickening is especially prominent in certain groups of brown cells that underlie the surface specks (Plate 2, Figures 1, 2.) In the center of these brown cell-masses one often finds small pockets produced by the collapse of one or two cells. In cellar storage the red spots become badly browned and sunken. The green spots may take a similar course but in many cases there is no marked change in their surface appearance. Under such circumstances, however, one often finds that the disease is spreading deeper into the tissue and that a pocket is being developed as a result of the shrinking of the cells (Plate 2, Figure 3).

The development of the spots depends greatly upon seasonal and storage conditions. When the weather is damp and foggy during the last weeks before harvesting, the spots on the red fruit surfaces develop rapidly and become black and sunken before the fruit is removed from the tree. After gathering, the spots develop most rapidly on apples placed in boxes and barrels in cellar storage. On apples placed immediately in cold storage the spots make but little or no development. When apples are stored in a warm, dry place and wither rapidly, brown spots are not developed. On the withered fruit the green spots often stand above the surrounding portions, forming smooth green elevations that are in marked contrast with the yellow withered skin of the apple. This resistance to withering is probably due to the abnormal thickness of the cell walls in the tissue of the spots. Like the Fruit Pit the Fruit Spot is often accompanied by a browning of the vascular tissue. In late stages of the Fruit Spot one sometimes finds

minute elevations at the lenticels in the center of the brown sunken areas.

It would be difficult to decide from the earlier descriptions given in the bulletins of the New Hampshire station (17) whether the Fruit Spot or the Fruit Pit was under special observation. The descriptions are better if taken as applying to the two diseases than if considered as applying to either to the exclusion of the other. The spraying experiments (17) were undoubtedly made upon the Fruit Spot. So far as the writer has been able to learn, a distinction between these two diseases has never been made.

An associated fungus.—As a result of spraying experiments made in the summer of 1906 the writer obtained data that agreed with those of Lamson (17) as to the value of fungicides in preventing the spotting of apples. Such results could be explained only by assuming that the disease was of fungous origin or that Bordeaux had some remarkable and undescribed effect upon the skin of the apple. The former supposition seemed far the more probable. As an initial test of the hypothesis, blocks of browned tissue were removed from beneath the epidermis of the apple and placed in sterile culture media. Agar and gelatin cultures in which the nutrient substance was furnished by a decoction of beets, beans, beef, or apples were tried with little but negative results. The growths upon the different bouillons were too varied to give any indication of a common fungus. It was noticed, however, that after sections of spots had been left in water for a few days they were overgrown by a fungus and matted together. The fungus was always the same and always started from the center of the spots. As a result of these observations liquid media were given a more thorough trial. Browned tissue was transferred to sterile distilled water and in four or five days the blocks were fastended to the bottom of the test-tube or Petri dish. In fourteen days a fungous mass six to ten millimeters in diameter had developed. Similar results were obtained with various bouillons, and while the growth was quite unlike in the different media, transfers from one to another proved that the fungus was the same in all. It was also found that the fungus had not been obtained in the agar and gelatin cultures because their surfaces dried too quickly to give it time to develop. Placing the cultures in moist chambers remedied this trouble, but the development was slower than that in liquid cultures.

This constant occurrence of the same fungus in the diseased tissue suggested that it might be the cause of the trouble. In

view of the fact that fungi had been reported as being present in late stages of Fruit Spot, but had not been found to be present in earlier stages and again that no fungus had been reported as a factor in producing the trouble, one did not seem justified in drawing any conclusions until further studies had been made. It was important to determine whether the fungus is present in the earliest stages of the spots and whether it can be made to produce similar effects by artificial inoculation. Also, it was of interest to know from what sources the fungus can be obtained.

SOURCES FROM WHICH THE FUNGUS HAS BEEN OBTAINED.

In the investigation of this phase of the subject some sixty lots of apples were tested and as many as eight hundred separate cultures made. More than ninety per cent, of the cultures made from the green spots and about eighty per cent. of those made from the red spots gave a pure growth of the same fungus More than fifty per cent. of the contaminations obtained from the red spots were due to *Sphaeropsis malorum*, Berk. Among the other fungi obtained in culture two species of Penicillium, an unidentified fungus and a particular species of bacteria seemed to be of more than accidental occurrence. The Sphaeropsis, howver, was obtained from spots larger and darker than typical, and the other contaminations almost entirely from late stages of the spot. It was found that the fungus could be isolated from spots covered with a smooth and glaucous epidermis as well as from those having a lenticel in the center. The compound microscope revealed the fact, however, that the spots that seemed to be covered by an unbroken epidermis in reality had a stoma at the center.

In the summers of 1907 and 1908 spots were tested for the fungus from their earliest appearance. The same fungus was obtained from these earliest stages as was found in the later ones. In 1907 cultures of the fungus were obtained from Talman Sweets and Gravensteins on August 21, and from Baldwins on August 28. In 1907 cultures of the fungus were obtained from Talman Sweets shipped from Delaware. In these as in all other cases the tissue for inoculation was removed from beneath the epidermis by means of a sterilized knife. At this time the spots had little or no brown corky growth beneath them.

Within the past two years the fungus has been isolated from apples obtained from Delaware, New York, Pennsylvania, Michigan, Maine and Massachusetts, from Toronto and Montreal in Canada, and from the following points in New Hampshire: Web-

ster, Durham, Lee, Wilton, Madbury, Walpole, Packer's Falls, Barrington. Deerfield, Dover and Nashua. It has been obtained from the following varieties: Baldwin, Greening, Northern Spy, Talman Sweet, Red Canada, Red Astrachan, Canada Baldwin, Fall Pippin, Bellflower, Gravenstein, Grimes Golden, Russet, Porter, Snow, Wealthy, Ben Davis, and Mann, besides a half dozen different sorts of native fruit. The spots on most of the above varieties are similar to those already described. On the native varieties and on the Talman Sweets the green spots are more common and such brown spots as occur usually have a bright red margin. The appearance on the Talman Sweets is quite similar to that described by Clinton (15) under the name of Fruit Speck.

LABORATORY INOCULATIONS.

During the winter and spring of 1906-07 numerous inoculation experiments were made. The apples used in these experiments were first washed either in alcohol or in a five per cent. solution of formalin. Spores from pure cultures of the fungus were introduced beneath the epidermis by means of a sterile platinum needle. From four to twelve inoculations and an equal number of check punctures were made on each apple. These inoculated apples were placed in moist chambers to await developments. More than a hundred apples were treated in this manner. Most of these were Baldwins, but Yellow Transparents, Manns, Astrachans, Red Canadas, Greenings, and Porters were also used. Baldwins removed from the culture chambers after two weeks time usually showed little or no contrast between the inoculations and punctures. The same condition was sometimes found at the end of three weeks. After four weeks time there was always a marked contrast (Plate 3, Figure 2.) In the punctures the needle path looked practically as clear-cut and fresh as when first made. The inoculations showed on the surface of the apple as brown sunken spots. A study of the underlying tissue showed that the cells around the needle path had shrunken and collapsed, making a much larger opening than the original one. The tissue was browned for a radial distance of one to three millimeters (Plate 2, Figure 4.) When vascular bundles were near the needle path the browning extended several millimeters farther along their course than in other directions. Free-hand and microtome sections of the brown tissue of the inoculations showed that but one fungus was present. There was a good growth of this, and its characteristics and its relations to the host cells were the same as

are later described for the fungus in the pockets of the host tissue (see page 359). Upon transfer to culture media inoculation tissue gave pure cultures of the above-mentioned fungus.

The rate of development of the inoculation spots varied greatly with the apple. All of the spots on a particular apple might be as fully developed at the end of two weeks as those on another apple, inoculated on the same day, from the same test-tube and placed in the same moist chamber, were in four weeks. Notes were taken on the acidity, dryness, and texture of such apples, but no conclusion could be drawn as to the cause of the difference in susceptibility of the different apples of the same variety. The results upon other varieties were the same as on the Baldwin except that on the Greenings, Yellow Transparents, Astrachans, and Porters the browning of the spot developed more rapidly. This fact would suggest that a soft tissue and a readily available water-supply are favorable to the rapid development of the fungus.

Repeated attempts were made to inoculate ripe unspotted apples by spraying spores over their surface and by dropping them into solutions that were full of spores, also by placing small pieces of spore-bearing agar on the lenticels. The apples were placed in a moist chamber and left until decay began, but only negative results were obtained. The apples used were Porters and Baldwins.

The above tests were made after the apples had lain in storage for some time and it seemed possible that the results might have been different had the inoculations been made before the apples had passed thru their "after-ripening" stage. Accordingly in the fall of 1908 similar inoculations were made on apples soon after gathering. The apples used were Talman Sweets and Baldwins.

The possibility of inoculation from spores already on the fruit was partly prevented by thoroly washing the apples in 95 per cent. alcohol before using.

Every spot or suggestion of one was marked. The apples were sorted into two lots by selecting two apples as nearly alike as possible as to number of spots, ripeness and appearance in general and placing one in each pile. One of these lots was placed in glass jars and water to which spores had been added in large quantities poured over the apples. After standing a short time the spore-bearing water was poured out leaving the apples and the inside of the jars well covered with spores. The other lot was similarly treated except that no spores were added to the water. All of the jars were closed and placed in a cool, poorly

lighted place. On December 12th the apples were removed from the jars and notes taken on the increase in the number of spots. Apples that had no spots when placed in storage were as a rule still unspotted. The number of new spots on an apple that was originally spotted was approximately the same as the number of old ones. The average number of new spots was approximately the same on the inoculated as on the uninoculated apples. The experiment gave no proof that the spores applied to the apples had in any way affected them. The new spots from both the inoculated and uninoculated apples gave pure cultures of the fungus in question. These spots had probably been produced by spores that had gained entrance to the stomata and lenticels earlier in the year but had not made sufficient development at the time of gathering to cause spots on the fruit. The results seem to indicate that spores rarely gain entrance to the mature fruit, also that there is a great difference in the susceptibility of different apples.

FIELD WORK.

From the theoretical as well as the practical standpoint it was of interest to determine when and under what circumstances the fungus gained entrance to the apple and how this infection could be prevented. Spraying experiments made in the summer of 1906 furnished some suggestions in this matter.

Fungicides. — The Bordeaux mixture used in these experiments was made with five pounds each of lime and copper sulphate to fifty gallons of water. The "K. L. B. P." was similar Bordeaux with kerosene-limoid, as recommended by the Delaware Agricultural Experiment Station (23), containing 15 per cent. of kerosene. The plots consisted of five trees each. The following data were obtained by actual count of the gathered fruit:

Fungicide.	Time of spraying.	Percentage of picked apples spotted.
None		99.7
Bordeaux	May 30	83
"	May 30 and June 8	69
"	June 2 and June 8	72
"	June 2 and June 21	42
"	June 21	56
K. L. B. P.	May 30 and June 8	86
K. L. B. P.	May 30 and June 21	36

These results show that the application made on June 21 was more effective than any other and would suggest that infection usually takes place after that time.

In the summer of 1907 further tests as to the time of infection were made. The Bordeaux used was of the 3—3—50 for-

mula. As the fungus had been found to make a poor growth in alkaline solutions it was thought advisable to try the effect of lime as a spray. Five gallons of lime were added to each fifty gallons of water for this mixture. A resin-lime-solution was also used. It was prepared by adding five pounds of lime and five pounds of resin fish-oil soap to fifty gallons of water. As it was not known that the fungus was the primary cause of trouble, it seemed possible that some compound with little or no fungicidal value, but which would stick to the fruit as well as the Bordeaux, might have a hardening effect upon the epidermis and thus decrease the spotting. Accordingly calcium phosphate was formed as a precipitate by mixing dilute solutions of lime and sodium phosphate. Two and a half pounds of lime and five pounds of sodium phosphate were added to each fifty gallons of water. The plots consisted of five trees each. The following results were obtained by actual count of the spotted and unspotted apples on the trees at the time of gathering.

Mixture.	Time of spraying.	Percentage of picked apples spotted.
None		33.8
Bordeaux	June 17, June 25, and July 9	1.1
"	June 25 and July 9	1.5
"	July 9 and July 27	1.7
"	July 27	20.4
Lime	June 25 and July 9	16.7
Resin lime	Jnne 25 and July 9	12.9
Calcium phosphate	June 25 and July 9	23.4

Spraying experiments similar to the above were made in the summer of 1908. The 15—10—50 lime-sulfur solution mentioned below was a self-boiled mixture containing fifteen pounds of lime and ten pounds of sulfur to each fifty gallons of water, and prepared according to the directions given in Circular No. 1, Bureau of Plant Industry (25.) The 9—6—50 solution was a similar mixture, having nine pounds of lime and six pounds of sulfur to each fifty gallons of water.

In the preparation of the K. L. B. mixture one pound of lime and one pound of sulfur were added to a gallon of water and the mixture boiled for thirty minutes. Seven and one-half gallons of kerosene and thirty pounds of lime were added to forty-one and one-half gallons of water and the mixture vigorously stirred and churned. The lime-sulfur solution was then added with further churning.

The resin lime mixture was the same as used the previous year. The strength of the Bordeaux is shown by the accompanying figures. Thus 2—3—50 Bordeaux has two pounds of copper sulfate and three pounds of lime to fifty gallons of water.

The first spraying was made June 15, the second June 26, the third July 15, the fourth August 1. The two orchards used were in the same field. The following results were obtained by actual count at the time of gathering:

Fungicide.	Applications.	Percentage of Picked Apples Spotted.
	Results on Talman Sweets.	
Bordeaux, 2-3-50	2 and 3	11.8
None		62.1
	Results on Baldwins, first orchard.	
Resin lime 5-5-50	1 and 2	36.1
L. S. Thomsen	1 and 2	54.3
L. S., 9-6-50	1 and 2	26.5
L. S , 15-10-50	1 and 2	18.7
Bordeaux, 2-3-50	1 and 2	22.2
None		62.1
	Results on Baldwins, second orchard.	
K. L. S. Mixture	2 and 3	3.4
Bordeaux, 3-3-50	2 and 3	2.4
" 1-3-50	1 and 3	7.3
" 2-3-50	1 and 3	9.3
" "	1 and 2	8.3
" "	1 and 4	10.8
" "	4	47.2
" "	1, 2, 3 and 4	1.2
None		48.8

The second orchard had been well pruned while the first had not; it was composed of trees eighteen to twenty years old while the trees in the first were twenty-five to thirty years old. The difference in the amount of spot in the two orchards is probably due to these facts.

The results show the various lime sulfur solutions to be efficient in controlling the fruit spot, and that a 1—3—50 Bordeaux gives fair results. They also show that the disease may be largely prevented by two sprayings and that one of these may be made as late as July 15. The application made Aug. 1, evidently had little effect upon the spotting of the fruit.

The above data will be of further interest when viewed in connection with the results obtained in the orchard inoculation experiments.

The disease was not so serious as the preceding season, but the results were just as marked. While the lime was beneficial and the resin lime even more effective, it can be seen that both were far inferior to Bordeaux. The calcium phosphate was as evident on the foliage and fruit at the close of the season as the Bordeaux, but it seemed to have had but little effect upon the disease. If it had any effect upon the skin of the apple it could not be detected. A study of the results obtained from the use of Bordeaux shows that the application made on July 9 was more effective than any other. It also indicates that applications made as late as July 27 may materially reduce the disease.

Inoculations.—Throughout the summer of 1907 a large stock of liquid flask-cultures was kept on hand. The spores from these were added to water or to a one per cent. sugar solution and applied to the trees by means of a bucket-pump spraying outfit. The cultures used were approximately of the same age and the number of them added to a given quantity of water was always the same. The sprayings were all made between four and six o'clock in the afternoon. At each time two trees were thoroughly treated with water containing spores and two others with the sugar solution. These trees were given a second spraying two or three days later. The next week other trees were treated in the same manner. All of the trees were Baldwins. It was not considered necessary to spray the check trees with sterile water as the applications made to the other trees did not amount to more than an ordinary dew, and dews were common during the time of making the experiments. The data secured showed no contrast between the trees sprayed with water and those treated with the sugar solution. The results are given in the first of the tables below. The data were obtained by actual count of the apples at harvest time.

Only one bearing Baldwin tree was convenient to the laboratory. Inoculation experiments similar to those described above were made on the limbs of this tree. No sugar solution was used, however, and the spores were applied to the individual apple by means of an atomizer. Some half-dozen limbs bearing from six to twelve apples each were treated at a time. The limbs were selected from different portions of the tree so as to eliminate the factors of light and moisture as far as possible. Only one set of limbs was sprayed more than once and this was treated twice a week thruout the season. The sprayings were all made between four and six o'clock in the afternoon. The sprayed apples were not covered or protected in any way. Although the tree was large it is readily seen that plenty of opportunity must have been given for the spores to be carried by the wind from the inoculated apples to others near them. The results obtained from this experiment are given in the second table below.

1

Trees sprayed between :	Percentage of picked apples spotted.
July 5 and July 27	70.4
July 27 and August 10	43.5
August 10 and September 12	38.9
Checks	33.8

2

Limbs sprayed between:	Average number of spots per apple.
July 2 and July 15	15
July 15 and July 31	13
July 31 and August 15	11
July 2 and August 15	28
Checks	9

The results varied greatly with the individual limb and tree. It was intended to compare the data obtained with the weather records but it was found at the close of the season that these were in an unsatisfactory condition and could not be relied upon.

Inoculation experiments similar to the above were carried on in the summer of 1908 and results equally as striking were obtained.

Each group of trees and each set of limbs was given six successive sprayings, the applications being made at intervals of two or three days. Canada Red and Baldwin trees were used. The following tables give the results obtained:

Baldwin trees sprayed between:	Percentage of picked apples spotted.
July 6 and July 19	74.5
July 20 and August 2	64.7
August 4 and August 14	82.1
Checks	48.8

Limbs sprayed between:	Average number of spots per apple Baldwin.	Canada Red.
July 8 and July 19	21.7	12.9
July 20 and August 2	66.7	100.4
August 4 and August 14	28.	8.7
Checks	10.8	1.8

Other inoculation experiments were made by tying sheets of rubber closely around Baldwin and Canada Red apples and filling the bags thus formed with water that contained an abundance of spores. Check apples were similarly treated with water without the addition of the spores. These sacks were left on the apples three days and then removed late in the afternoon. The following table gives the average ratio of increase in number of spots per apple:

Date of Inoculation.	Ratio of increase in number of spots. Baldwin.	Canada Red
July 9	0	3.4
July 14	6.1	20.0
July 18		12.0
July 29	2.5	3.2
August 1	15.0	3.0
August 8	2.1	4.8
August 11	3.4	1.3

Many of the treated apples had fallen before gathering time and the above averages were taken from a limited number of specimens. This probably accounts for the great variation in results. The individual results probably should not be given great weight, but the table as a whole shows the possibility of inoculation and is quite significant.

One would seem to be justified in concluding from the sets of data above that the month of July is the time when the majority of the infections naturally occur. In 1907 the first half of the month seems to have been most favorable for infections and in 1908 the last half.

On August 30, September 7, and September 12, 1907, attempts were made to inoculate Baldwins and Northern Spies by introducing the spores under the skin of the apple by means of a sterile platinum needle. Six inoculations and six punctures were made on each apple. The apples were left on the tree till gathering time, October 10. A hard corky growth developed around the needle path in both punctures and inoculations. No difference could be seen in the two at the time of gathering and no change in either was apparent in storage. Tissue from the inoculations when transferred to culture media either gave no growth or a growth of bacteria. The fungus was evidently unable to develop in the column of cider that must have filled the needle path after inoculation. This fact is in agreement with data given later showing that the fungus did not develop on Baldwin cider made from apples gathered the last of August, even when this was diluted to one-third its original strength.

CHARACTERISTICS OF THE FUNGUS.

In order to learn as much as possible of the nature and identity of the fungus it has been grown upon a large number of culture media. Except where otherwise stated the decoctions used were prepared in the manner prescribed in bacteriological and pathological texts.

In all liquid cultures, except with a few very unfavorable media, the fungus began its growth in the bottom and on the sides of the vessel. After four or five days the entire surface that was under water was thickly dotted with minute colonies. (This was not true of the sides of Erlenmeyer flasks nor of the upper wall of a slanting test-tube.) The number of colonies was dependent upon the amount of surface and the number of spores introduced rather than upon the quantity of solution. These colonies soon developed into hemispherical gelatinous

masses that could not be readily crushed when placed on a slide under a cover-glass because of the ease with which they slid from between the glass surfaces (Plate 3, Figure 4.) A microscopic study of the material showed that its gelatinous nature was due to the fact that the hyphae upon coming in contact with each other became fastened together. This attachment often extended to a breaking down of the walls between the hyphae and the merging of two cells into one. The result was a peculiarly anastomosed fungous mass. Spores were most abundant on the surface of these masses but were produced thruout the colony. They were hyaline, consisted of from one to five cells and were from 2 to 3 microns wide by 20 to 60 microns long. The hyphae were septate and about 3 microns in diameter. The spores were cut off from the tip of knob-like projections on the side of the hyphae as described below for the agar cultures. A few days later these colonies would go to pieces and a growth would soon begin to form on the surface of the liquid. This growth was light-colored at first and of uniform texture throughout, but later had a very definite zonation both as to color and structure (Plate 5, Figure 2). On the surface was a layer of hyaline conidiophores arising from a zone of vertical brown hyphae that formed the upper margin of a dense black stromatic layer. The hyphae of the stroma were thick-walled, abundantly septate, and from 3 to 6 microns in diameter. Beneath it was a less compact layer composed of a mixture of coarse and fine threads. In some cases there was a series of such zones as have just been described. This may have been due to the fact that the liquid had been left on the top of the stroma when examinations of the flask were made. In a five months old flask culture it was noticed that numerous, somewhat hemispherical elevations had developed on the surface of the stroma (Plate 5, Figure 1.) An examination of cross sections of these showed that numerous thimble-shaped cavities had developed on their surfaces and that where these were present the layer of conidiophores was wanting. These cavities were bordered by rather dense layers of mycelium and contained parallel erect hyphae with thinner-walled and almost isodiametric cells that in some cases gave a suggestion of presporogenous tissue.

In agar cultures the conidia were produced beneath the surface of the agar. One spore would be produced and pushed aside to give way to a second, and this followed by a third and so on indefinitely (Plate 7, Figure 2.) In young cultures nearly all of the mycelium was beneath the agar, later a mass of coarse aerial hyphae developed (Plate 4, Figure 5). In such

cases a black stromatic layer was formed just beneath the surface of the agar.

Chlamydospores were common in all old cultures.

Conidia germinated rapidly in hanging-drop cultures (Plate 6, Figures 1, 2, 3). Under similar conditions chlamydospores germinated as shown in (Plate 7, Figure 4). Each cell of the stromatic mass in old cultures seemed to have the power to send out hyphae when transferred to a fresh medium (Plate 7, Figures 5, 6).

The conidia from very old cultures did not germinate but the chlamydospores and thick-walled hyphae retained their vitality a long time. Germination was secured from chlamydospores in an agar culture that was twenty-six weeks old and in which the medium had been hard and dry for more than five months.

The fungus developed as well in cultures at a temperature of 15 degrees as at 20 degrees, but made a poor growth at 30 degrees. It was killed by an exposure for five days to a temperature of 37 degrees. It was evidently not injured by prolonged exposure to low temperatures, as it was repeatedly isolated from apples which had been in cold storage for several months. It was also obtained in culture from an apple which had been exposed for eight days to a temperature varying from—28 degrees to—6 degrees C.

RELATION OF THE FUNGUS TO NUTRIENT MEDIA.

The fungus grew best on acid media and was very sensitive to sugar in culture solutions. In most culture media that lacked sugar the fungous growth was white or pink, but where sugar was present as the principal ingredient it was olive or black. The solution given below was found to give a very satisfactory growth of the fungus and was used for all stock cultures. For the sake of convenience it will be referred to hereafter as solution *A*.

Glucose or sucrose	10 grams
Apple bouillon	25 c.c.
Sodium chloride	1 gram
Liebig beef-extract	1 gram
Peptone	2 grams
Water	975 c.c.

The following notes give some of the characteristics of the fungus in various culture media:

In water.—Blocks of infected apple tissue two or three millimeters in diameter gave a good growth of the fungus when

dropped into sterile tap or distilled water. In less than a week the fungus had fastened the blocks to the bottom of the test tube and later spores were produced in limited numbers. The hyphae were about 2 microns in diameter, hyaline, and sparingly septate. Spores germinated readily in distilled water, producing hyphae several hundred microns long in a few days.

In peptone beef bouillon.—In this medium the growth was a pinkish white, beginning as colonies on the walls of the flask and later forming a shiny pink layer on the surface of the liquid. There was a fair production of spores. The hyphae were coarser and shorter than those described above.

In glucose bouillon.—Olive colonies developed on the side of the test-tube, followed by a dark olive growth on the surface. Spores were produced in abundance and were always hyaline. The hyphae were thicker-walled and more abundantly septate than in other media.

In solution A (see above).—The growth was more rapid and the spores were produced in greater abundance than in glucose bouillon. The hyphae were hyaline except in the surface growth of very old cultures.

In milk.—The fungus developed only on the surface of the milk. After seven days a slimy pink band of fungous growth would be seen on the walls of the test-tube and a layer of brown whey two to five millimeters deep would be found on the top of the milk. The remainder of the medium was unchanged and the whey was separated from the milk by means of a film-like layer of curd. At the end of fourteen days the whey had a depth of ten to fifteen millimeters and in three weeks had often nearly reached the bottom of the test-tube. The layer of curd always separated the milk from the whey and in old cultures formed a solid white mass several millimeters deep in the bottom of the tube. Cultures in fermentation-tubes showed that no gas was produced. The hyphae as developed in milk were short, thick, and much branched. Spores often produced other spores by a sort of budding process.

In peptone potato bouillon.—The fungus made a good growth. No browning of the solution was evident in nineteen days but at the end of two months it was browned to a depth of two centimeters and later was browned thruout.

In peptone corn-starch bouillon.—The results were exactly as obtained in peptone potato bouillon except that the browning developed more rapidly.

In potato-starch bouillon.—The fungus made a fair growth. The hyphae were hyaline. The solution was not browned.

In corn-starch bouillon.—The growth was like that in potato-starch bouillon except that in old cultures the hyphae became olive.

In apple bouillon.—Though the tubes were repeatedly inoculated, the fungus did not develop. The bouillon was made from Baldwins gathered the last of August.

On apple cylinders in water.—The fungus made a fair growth. The hyphae were coarse and of a dark olive color. But few spores were produced. The apple tissue became brown in old cultures, a thing which did not happen in the check-tubes.

FIGURE 13. Stab culture of *Cylindrosporium Pomi* on beef bouillon gelatin.

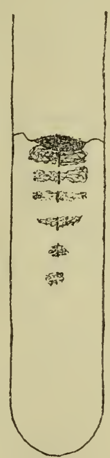


FIGURE 14. Stab culture of *Cylindrosporium Pomi* on beet agar.

On potato cylinders in water.—A black slime developed, upon the surface of which were tufts of hyaline hyphae. The spore production was much like that obtained in milk.

On beef bouillon gelatin.—The development was very slow when surface inoculations were made. Liquefaction was scarcely evident in seven days but developed more rapidly after that time. It was crateriform in character. From three to eight weeks were required for complete liquefaction. In old cultures the liquid was slightly browned. In stab cultures the growth was absorbent (Figure 13).

On beet bouillon gelatin.—The hyphae were darker than those in the beef gelatin and the liquefied gelatin was brown from the first.

On apple bouillon gelatin.—The development was slower than in other gelatins. The fungous mass was olive-black. The gelatin was liquefied and browned.

In beef bouillon agar.—The surface growth was umbonate. It was pink in color and had the appearance of a bacterial culture. Later the growth sometimes became darker at the margins. The hyphae were abundantly septate and the cells often swollen to circular form and to several times their usual width. Typical spores were not produced.

On glycerin agar.—The appearance of the colonies was similar to those on beef agar but they soon turned to an olive color. The hyphae appeared normal and spores were produced in abundance. But few aerial hyphae developed.

On maltose agar.—The colonies were pink at first but later were covered with hyaline aerial hyphae. The development was slow and but few spores were produced.

On beet agar.—In stab cultures the growth was umbonate, and arborescent (Figure 14). The hyphae were hyaline with the exception of an olive mass on the surface in the center of the colony. Spores were produced beneath the agar.

On solution A agar.—The growth was entirely beneath the agar at first. Later an olive stromatic mass developed at the surface and from this were produced numerous aerial hyphae (Plate 4, Figure 5). The spores were abundant and were produced beneath the surface.

Miscellaneous media.—The fungus has been grown on various other media and under various conditions in an effort to produce other fruiting forms. Among the substances used were rice, ground whole wheat, hominy, peptone, corn stalks, and various phosphate and potash solutions. On rice and hominy the growth was white on the surface but olive beneath. On ground whole wheat it was black thruout and gradually turned the wheat to a deep brown. In all peptone mixtures the culture medium was browned, the greater concentrations being changed most in color. Sodium ammonium phosphate added to a sugar solution caused a slimy pink growth to develop, instead of the usual coarse olive fungus. This was not true of potassium phosphate.

The above culture notes show that while the fungus is responsive to changes in food material it is able to make some sort of growth on almost any medium.

Acidity. Enzymes.—Since the acidity of the cell-contents of the apple had been considered an important factor in the production of the "Stippen," it was thought advisable to test whether the fungus in question increased or decreased the acidity of culture media. Thirty 100 c.c. flasks were thoroughly cleaned as for physiological culture work and 50 c.c. of solution A added to each. After sterilization twenty of these were inoculated with the fungus. All thirty of the flasks were kept under the same conditions for sixteen days. At this time the acidity of the inoculated flasks and those not inoculated was determined by titrations. The large amount of sugar present reduced the sensitiveness of the indicator to such an extent that no definite results were obtained. There had at least been no marked change in acidity.

Neutral litmus milk-tubes were inoculated and were watched for any indication of acidity. The lavender color disappeared only to give place to the brown of the whey.

Some culture material which had originally been solution A but which had had the fungus growing on it for more than five months, produced but an extremely scant growth after sterilization and reinoculation. Tests were made to determine whether the reduction in growth was due to the production of some harmful substance or to lack of food material. 25 c.c. of this used solution were placed in each of fourteen 100 c.c. flasks. To two of these was added as much of each of the original food materials as had been added to an equal quantity of water in the beginning. In another two the peptone content was increased as described above but the solution left otherwise unchanged. The other food constituents were added to other flasks in a similar manner, and two flasks were left unchanged as controls. The flasks were all inoculated with the usual fungus. The ones to which all the original constituents had been added gave a luxuriant growth of the fungus. The flasks to which sugar had been added came next in amount of development and those in which the apple content had been increased came third. The addition of peptone increased the growth but the flasks to which beef extract and sodium chloride had been added gave no better develpoment of the fungus than was obtained in the controls. These results would suggest that the fungus failed to make the usual development in old culture media because of lack of food material rather than from any harmful compound produced, and also that the acidity of the solution must have been decreased by the growth of the fungus. Beef extract and sodium chloride

were evidently not needed by the fungus in the quantity in which they were added to solution A.

Efforts were made to determine whether the browning that accompanied the fungus in the apple tissue and also in various other culture media was due to an enzyme or other product of the fungus. A part of the old solution A, previously described was sterilized and strips of sterile uncooked apple tissue dropped into it. Strips of apple were similarly placed in new solution A. After three weeks the tissue was unaffected in both of these. This used culture solution was also added to tubes of milk but no change in color was apparent. Some of the old culture solution was passed through a Chamberland filter and its effects upon apple tissue tested, but with only negative results.

The toxic effect of malic acid and tannin on the fungus was tested in Van Tieghem cells. Germination was entirely inhibited by a .5 normal solution of malic acid and greatly retarded by .125 *n* solution. The fungus made a fair growth in the latter solution. With tannic acid, germination was inhibited by a .025 *n* solution and only an abnormal growth was made in .0125 *n* solution. The fungus gave a fair growth in .00625 *n* solution.

According to Alwood and Davidson (24), ripe Baldwins have .039 gram of tannin and .68 gram of acid as malic to each 100 grams of juice from the ripe fruit, *i. e.*, the juice would be about .002 *n* solution of tannin and about a .1 *n* solution of malic acid. These data agree with the fact that the fungus makes a fair growth on ripe apples. They show that any large increase in the acidity of the apple would prevent the development of the fungus in a cider culture. The tannin in the surface zone of the apple is probably greater than the above figures would indicate, as tests made by the writer as well as the work of Zschokke (6) show that the tannin content in the hypodermal parenchyma is much greater than in the more deeply seated tissue. It is interesting to note in connection with the extreme sensitiveness of the fruit spot fungus to tannin that Alwood and Davidson (24) found the Baldwin apple to be comparatively low in tannin content.

THE RELATION OF THE FUNGUS TO THE HOST.

In connection with the other work upon the disease a microscopic study was made of the fungus as found in the tissue of the spots. In the preparation of material several killing agents were used, among these were absolute alcohol, various strengths of chrome-acetic, weak Flemming, Carnoy's fluid, picric and picro-acetic. The last two were found to be far the most satisfactory. Their superiority lay in the fact that they did not cause the epi-

dermal and closely related cells to become so hard and brittle as the others did. Various contrast stains were tried on the tissue but none found more satisfactory than Delafield's haematoxylin followed by erythrosin. Both the apple tissue and the older threads of the fungus held the haematoxylin quite persistently. The best results were obtained by staining fifteen or twenty minutes in haematoxylin, washing in acid alcohol until the stain had almost disappeared, transferring to water and then to erythrosin and leaving the slide in the latter stain for several hours. Erythrosin gave fair results when used alone. Free-hand sections were found very serviceable but serial microtome sections were generally used. Various thicknesses of sections were tried. Thin ones were best for a study of the stomata and lenticels, but sections 40 to 60 microns thick were found more satisfactory in tracing the mycelium of the fungus. This is not surprising when we bear in mind the large size of the apple cells and extreme fineness of the mycelium.

Every form and stage of the disease was studied. More than a hundred spots were sectioned and the fungus was found in every spot. This was true of the spots located at stomata and covered by a smooth epidermis as well as of those situated at the lenticels. In the younger stages the fungus had made very scant growth. In several cases it was actually identified in but one or two places in the entire series of sections and these possibly a millimeter or more apart. The threads were hyaline, granular, and apparently non-septate. They were extremely fine, in some cases being less than 1 micron in diameter. They had exactly the same appearance in these young stages of spots as when grown in extremely dilute solutions.

A study of the later stages showed that the fungus had accompanied the browning of the tissue in its spread. In the lenticels of the red spots one sometimes found a band of thick-walled promiscuously arranged cells passing through the organized layers of the lenticel, thus connecting the browned tissue beneath with the break in the epidermis above (Plate 6, Figure 4.) In such cases the fungus was present in both the band of cells and the more deeply seated shrunken tissue. In the green spots the fungus was found both in the groups of brown cells beneath the lenticel and in those a short distance from it (page 341). In many cases it seemed to have remained encysted in the center of these groups of thick-walled cells (Plate 2, Figure 1, 2). In others it had broken through them, spreading deeper into the tissue, browning and killing the cells along its course (Plate 2, Figure 3). In no case

was the fungus definitely traced from one of these pockets to another. Careful search was made for hyphae that had penetrated the cell-walls but none were found. In some cases they seemed at first sight to be within the cells, but a closer observation showed that the cells had collapsed and that the hyphae were in the cavity they had left. The mycelium in the pockets of the host tissue was coarse, septate, thick-walled, and brown, such as was often obtained in the stromatic layers of cultures. From these coarse threads arose fine hyaline apparently non-septate ones which spread out into the apple tissue. Chlamydespores were common on the coarse hyphae but conidia were never found within the apple tissue.

As was previously mentioned spots that had become much enlarged, sunken, and browned sometimes had a minute elevation in the center (page 342). Sections through these showed that the epidermis had been raised in this manner through the agency of a fungous mass beneath. A dense stroma from 60 to 100 microns in diameter and about 50 microns deep, occupied a pocket beneath the lenticel or stoma. Equally dense layers extended laterally from this between the host cells for a radial distance of 100 to 400 microns. The stromatic mass was hyaline or of a yellowish tint and was composed of closely woven, septate, thick-walled hyphae that had a diameter of about 5 microns. In spots in which the fungus had not yet broken through the epidermis a somewhat conical fungous mass that seemed to be composed of fine granular hyaline threads arose from the upper surface of the stroma (Plate 4, Figure 2.) In older stages this had been forced through the epidermis as a layer of erect hyaline sporophores (Plate 4, Figures 1 and 3.) The sporophores were extremely thick-walled, usually septate, and either branched or unbranched. The conidia were produced in a manner similar to that already described for the fungus in cultures (Plate 7, Figures 1 and 2.) They were hyaline, from one-to-five-celled, 2 to 2.5 microns in diameter, 15 to 70 microns long, often larger at the basal than at the free end, and were variously curved and contorted.

IDENTITY OF THE FUNGUS.

The descriptions of the previous pages together with the various figures to which references have been given furnish a fairly complete morphology of the fungus in question. In young stages of fruit spots and in all dilute solutions the hyphae are hyaline, granular, apparently non-septate, and are from 1 to 2 microns in diameter. In more concentrated solutions they are usually

granular and hyaline, have a diameter of 2 to 8 microns and are broken up into cells having a length of 20 to 100 microns. Stromatic hyphae and those in the pockets of the host tissue are various shades of yellow and brown in color and are composed of thick-walled, somewhat barrel-shaped cells about 5 microns in diameter and 6 to 20 microns in length. Chlamydospores are a common accompaniment of these coarse threads. They are brown, thick-walled and have a diameter of from 4 to 6 microns. In young liquid and agar cultures conidia are produced from knob-like projections on the side of long, branching, septate, apparently vegetative hyphae. Many conidia are produced from a single one of these projections. The conidia are hyaline, granular, one to five-celled, from 2 to 2.5 mincrons in diameter and from 15 to 80 microns in length. In outline they are straight, curved, or sigmoid. They germinate rapidly, sending out one or more hyphae from each cell. In some media the germinating spores produce other spores directly without the development of a mycelium. In old cultures a stroma is produced from which arises a layer of hyaline conidiophores. They are from 20 to 60 microns long and differ from the vegetative hyphae but little save in a reduction in length and branching. The conidia and their manner of production are similar to that described above. Pustule-like cavities having no special peridum develop at stomata and lenticels beneath the epidermis. Later they rupture the epidermis, exposing a layer of hyaline, septate, sparingly branched conidiophores. The conidia are produced from knob-like projections on the conidiophore and have the characteristics given above for spores produced in culture media.

The structures of the pustules and of the spores places the fungus in the genus *Cylindrosporium.* Of the species in this genus enumerated in Saccardo, it bears closest resemblance to *Cylindrosporium Ranunculi* (Bon) Sacc. This fungus was isolated from leaves of *Ranunculus aeris* and *Ranunculus bulbosus* in Italy. The writer is not inclined to consider the two fungi identical. For the Fruit Spot fungus he suggests the name *Cylindrosporium Pomi.*

Cylindrosporium Pomi Brooks, sp. nov.—Acervulis pallidis, subeffusis, primo subepidermicis, dein erumpenti-liberis. Conidiis hylinis,. granulosis, filiformibus, rectis vel flexuosis, 15—80 microns X 2—25 microns. In fructu *Mali Mali* (L.) Britton, in America Boreali.

Summary and Conclusions.

The writer considers that the facts and indications given justify the following conclusions:

1. The Fruit Spot of New Hampshire apples is due to a parasitic fungus, *Cylindrosporium Pomi* Brooks.

2. The fungus gains entrance to the apple in July or early August, a time when the stomata are being torn open and the protecting layers of the lenticels are not yet formed, a season when the metabolism of the apple is extremely great and the transpiration stream necessarily large.

3. The fungus makes its way into the intercellular spaces beneath the stomata and between the cells of the surface zone obtaining the substance necessary for its existence from the transpiration stream and from the rapidly maturing host cells.

4. If the fruit is attacked before the cells have lost their power er to respond to external stimuli the fungus is soon partially surrounded by a layer of brown, thick-walled cells which may serve as a barrier to its further nutrition. In such cases the results are not altogether unlike those obtained from a minute puncture or an insect sting.

5. If, however, the fungus attacks the host cells when they are nearly mature, it finds conditions more favorable for its development, because the cell sap furnishes more satisfactory food material and the cells are at the same time unable to respond to its presence. The result is a more vigorous development of the fungus and a rapid browning and drying of the host tissue.

6. The chlamydospores and sclerotial masses of the fungus are the probable agencies in carrying the disease through the winter.

7. Conidia have not been found on the host in the fall. They probably develop from sclerotia and pycnidia in the following spring on apples that have lain on the ground over the winter, and thus become the agency in starting the disease the next season.

8. Spraying with Bordeaux is a preventive for the disease. Applications made late in June or early in July are as effective as those made earlier in the season.

9. By his references to the work reported from other stations the writer would not be understood to imply that the disease here under special consideration is *identical* with that described from any other section. However, he does not find anything in some of these reports to show that the Fruit Spot which is com-

mon in New Hampshire *may* not sometimes have been included along with the Fruit, Pit in these descriptions. Further, this study leads the writer to the conclusion that the fact that particular pathological conditions may originate without the presence of any foreign agency, should not be taken as proof that very similar results may not be due to the presence of a parasitic fungus in the host tissue.

The writer wishes to acknowledge his indebtedness to Prof. H. H. Whetzel of Cornell University, Prof. W. J. Morse of the Agricultural Experiment Station of Maine, Dr. J. B. Dandeno of Michigan State Agricultural College, Prof H. R. Fulton of Pennsylvania State College, Prof. W. T. Macoun of the Central Experimental Farm, Ottawa, Canada, and Prof. C. P. Lounsbury of the Department of Agriculture, Cape Town Africa, for specimens of spotted fruit.

Literature Cited.

1. **Sorauer, P.** Obstbaumkrankheiten, 100. Berlin, 1879.
2. **Fries, E.** Systema Mycologium 3: 504. 1832.
3. **Reichelt, K.** Pomolog. Monatshefte 1884: 335. 1884.
4. **Frank, A. B.** Die Krankheiten der Pflanzen, 588. 1880.
5. **Wortmann, J.** Ueber die sogenannten "Stippen" der Aepfel. Landw. Jahrib. 21: 663—675. 1892.
6. **Zschokke, A.** Ueber den Bau der Haut und die Ursachen der verschiedenen Haltbarkeit unserer Kernobstfrüchte. Landw. Jahrib. der Schweiz 11: 153—197. 1897.
7. **Cobb, N. A.** Brown or Bitter Pit. Agric. Gaz. N. S. Wales 9: 683. 1898.
8. **Craig, J.** Dry Rot, Brown Spot of Baldwins, Spot of apples. Rep. Canada Exp. Farms, 1896 and 1899.
9. **Selby, A. D.** Brown spots beneath the skin of apple. Bull. Ohio Agric. Exp. Sta. 79: 135. 1897.
10. **Jones, L. R.** A spot-disease of the Baldwin apple. Rep. Vt. Agric. Exp. Sta. 5: 133—134. 1891.
11. **Jones, L. R.** The Brown Spot of the apple. Rep. Vt. Agric. Exp. Sta. 12: 159—164. 1898.
12. **Stewart, F. C.** Is the Baldwin Fruit Spot caused by fungi or bacteria? Bull. N. Y. Agric. Exp. Sta. 164: 215—219. 1899.
13. **Stewart, F. C.** Fruit Spot. Bull. N. Y. Agric. Exp. Sta. 191: 296—297. 1900.
14. **Clinton, G. P.** Baldwin Spot. Rep. Conn. Agric. Exp. Sta. 1903: 302.

15. **Clinton, G. P.** Fruit Speck. Rep. Conn. Agric. Exp. Sta. 1905: 264.
16. **Longyear, B. O.** Fruit Spot. Special Bull. Mich. Agric. Exp. Sta. 25: 14. 1904.
17. **Lamson, H. H.** The Brown Spot of Baldwins. Bull. N. H. Agric. Exp. Sta. 27, 45, 65, 101.
18. **Pick, H.** Bot. Centralbl. 16: 281—284; 314—318; 343—347; 375—383. *pl.* 1. 1883.
19. **Pfeiffer, O.** Ann. Oenol. 5: 271—315. 1875.
20. **Bigelow, Gore & Howard.** Studies on apples. Bull. Bur. Chem. U. S. Dept. Agric. 94: 1—100. *pl.* 1—5. 1905.
21. **Morse, F. W.** Chemical changes in apples during storage. Bull. N. H. Agric. Exp. Sta. 93: 82—88. 1902.
22. **Otto, R.** Landw. Versuch-Stat, 56: 427—439. 1902.
23. **Close, C. P.** Bull. Del. Agric. Exp. Sta. 68: 1—23. 1905.
24. **Alwood, Davidson & Moncure.** The chemical composition ot apples and cider. Bull. Bur. Chem. U. S. Dept. Agric. 88: 1—46. 1904.
25. **Scott, W. M.** Self-boiled lime-sulphur mixture as a promising fungicide. Circular, Bur. of Plant Ind. U. S. Dept. Agric. No. 1. 1908.

Explanation of Plates 1—7.

Plate 1.

Fig. 1. Baldwin showing young stages of the Fruit Spot.
Fig. 2. Baldwin showing later stages of the Spot.

Plate 2.

Figs. 1 and 2. Section through green spots of Baldwins showing a browning in the surface cells and pockets in the adjacent tissue. The fungus can be plainly seen in some of the largest pockets.

Fig. 3. Section through a green spot of a badly withered Baldwin, showing the thick-walled cells of the surface zone from which has later extended the large mass of shrunken brown cells beneath. The fungus can be seen in the pockets in this shrunken tissue.

Fig. 4. A cross-section of a thirty-four days' old inoculation on a Baldwin. The mycelium may be seen in the needle path and also closely pressed against the walls of the withering cells.

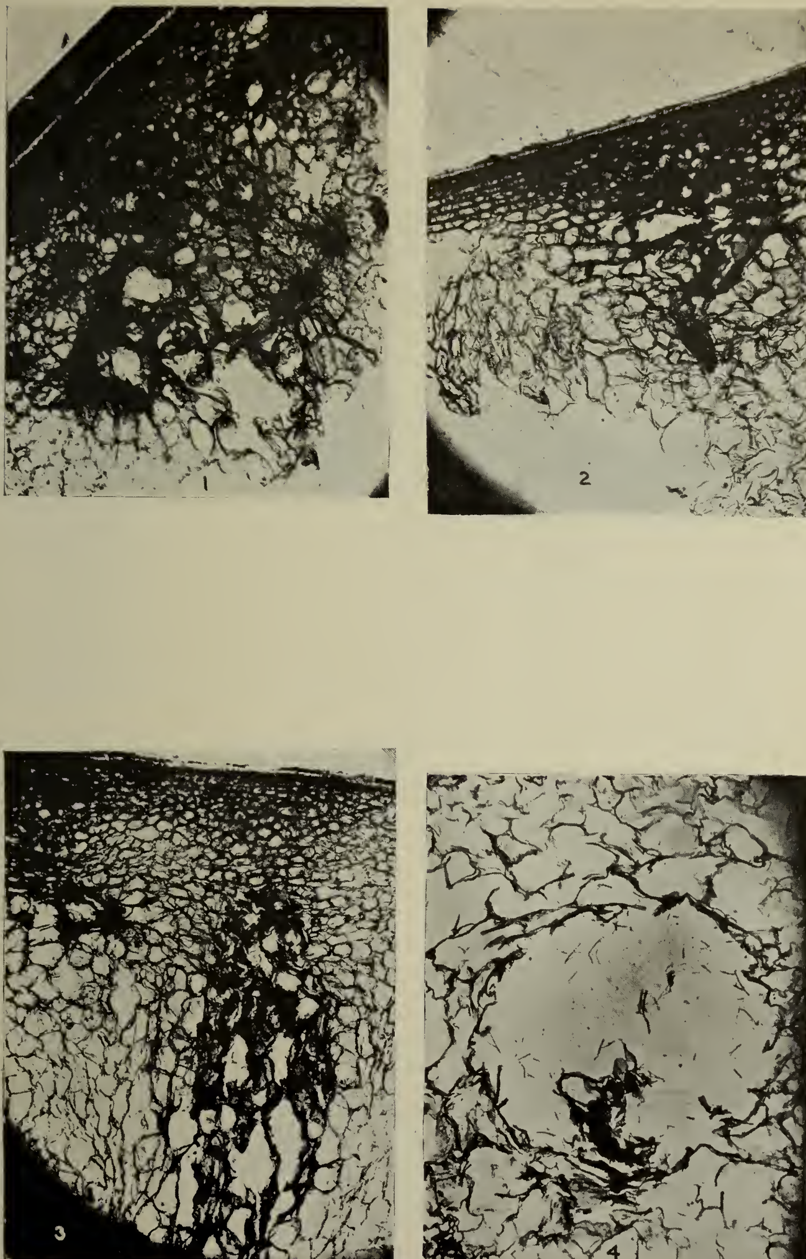
Plate 3.

Fig. 1. A cross-section of an apple to show the location of the large bands of conducting tissue.

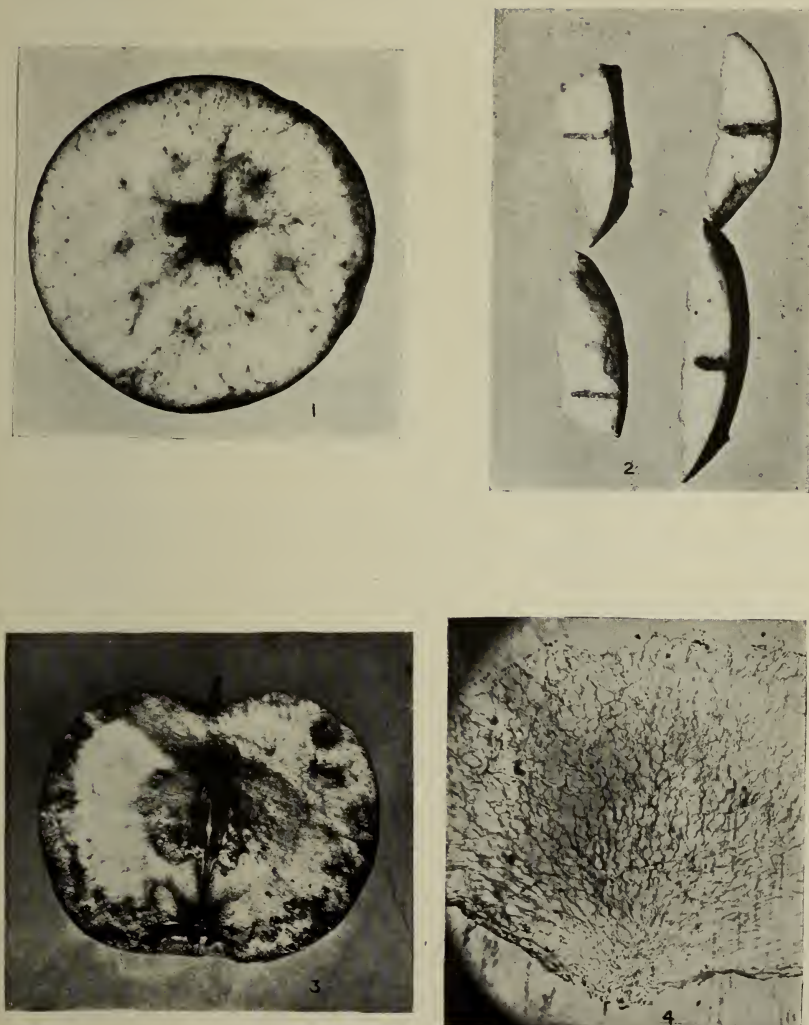
Fig. 2. Inoculations and punctures from a Baldwin after fifty days. The two at the right are inoculations.

Fig. 3. A section of an apple of which the tissue in the region of the vascular system is browned.

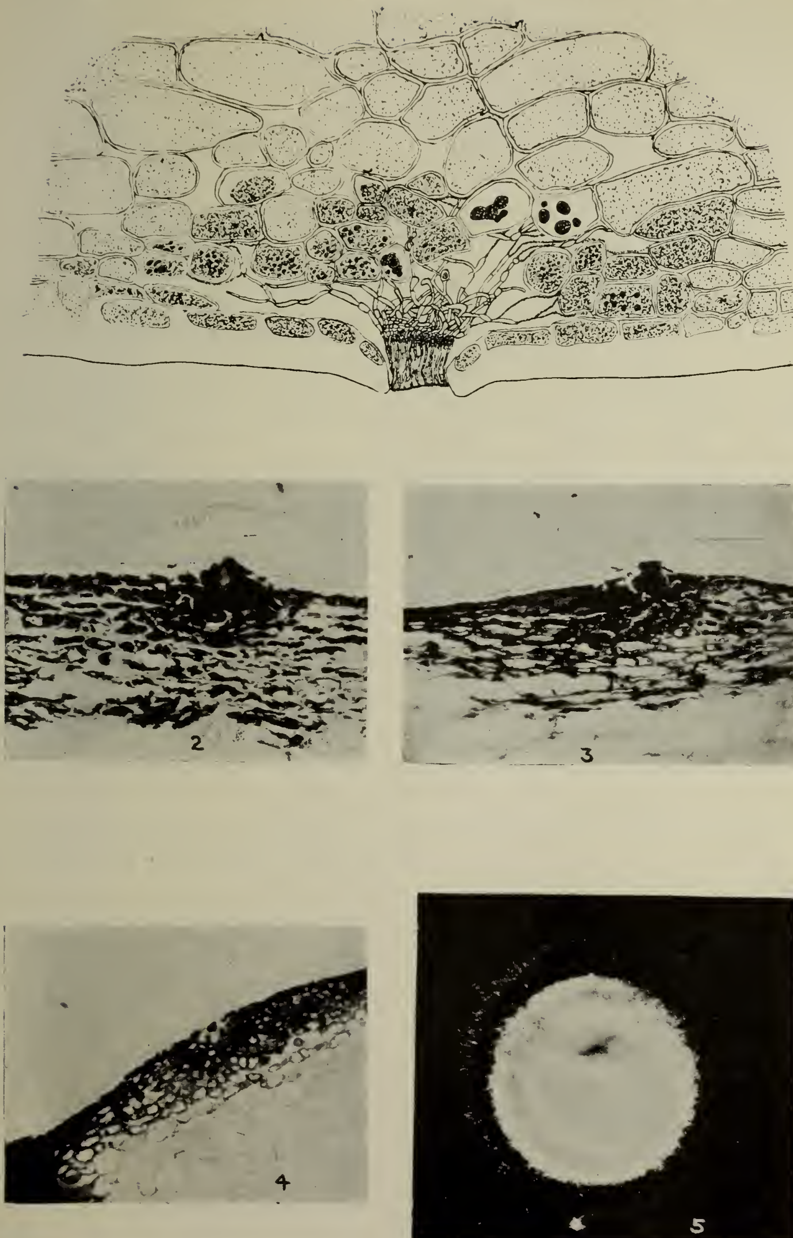
THE FRUIT SPOT OF APPLES.



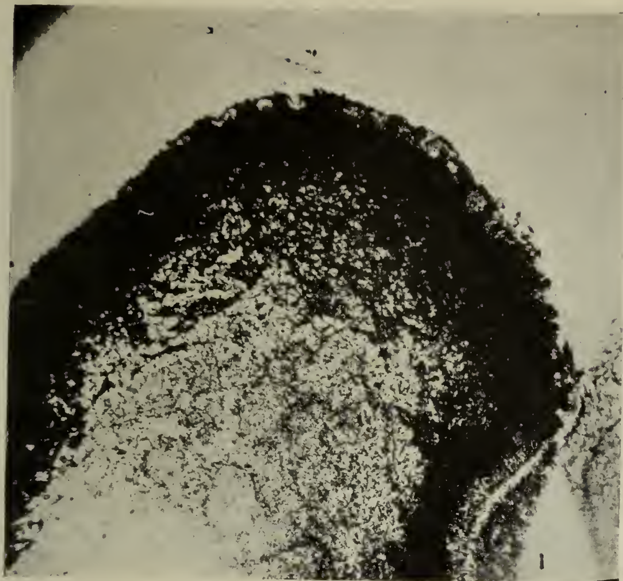
THE FRUIT SPOT OF APPLES.

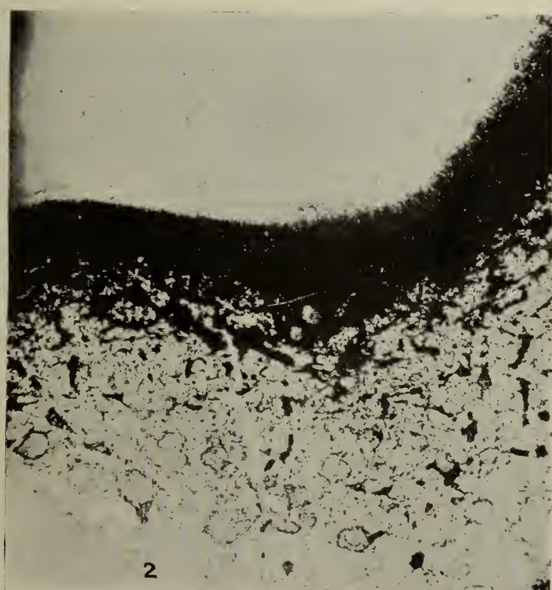


THE FRUIT SPOT OF APPLES.

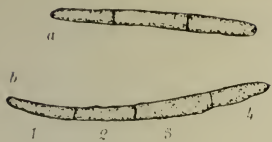


THE FRUIT SPOT OF APPLES.

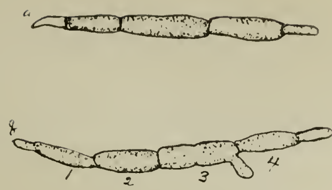




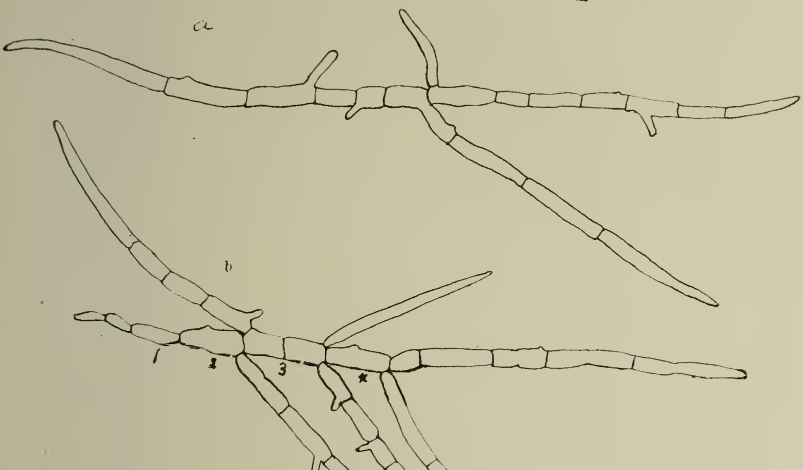
THE FRUIT SPOT OF APPLES.



1



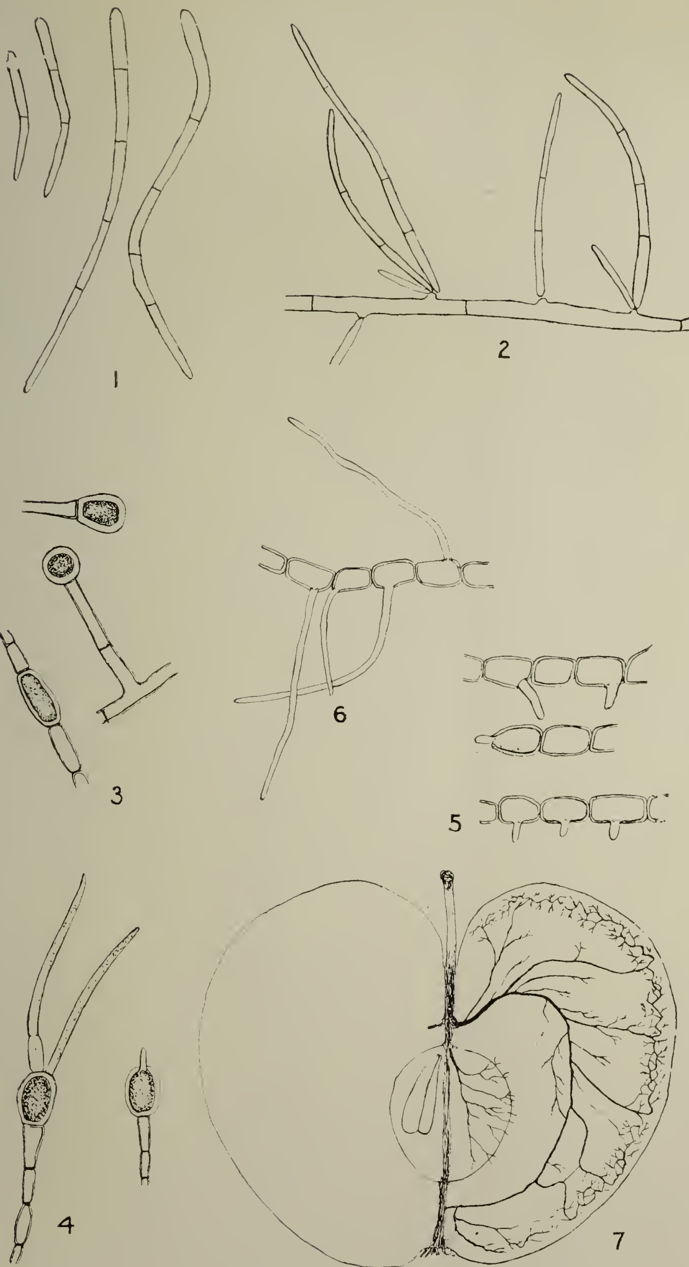
2



3

4

THE FRUIT SPOT OF APPLES.



THE FRUIT SPOT OF APPLES.

FIG. 4. A section of a typical colony from the walls of a ten days' old culture of solution A. The lower side as shown in the plate was attached to the wall of the test tube.

PLATE 4.

FIG. 1. A sketch of a spot showing the developing stroma and sporophores.

FIG. 2. A late stage of the Fruit Spot, showing the stromatic layer of the fungus with a conical mass of immature sporophores above it.

FIG. 3. A later stage of the spot showing the stroma, the shrunken tissue beneath, and the sporophores pushing through the lenticel above.

FIG. 4. A lenticel of an apple with normal tissue beneath it.

FIG. 5. Fungus as grown in agar Petri cultures.

PLATE 5.

FIG. 1. A section of one of the minute elevations from the stroma of a five month's old flask culture. The pustule-like cavities are shown in the upper portion.

FIG. 2. A cross-section of a stroma from a liquid flask culture showing the layer of conidia and conidiophores.

PLATE 6.

FIG. 1. Spores from cultures in solution A.

FIG. 2. The same spores after remaining twenty-one hours in Van Tieghem cells.

FIG. 3. The same spores after forty-two hours.

FIG. 4. A drawing of a section through an early stage of a fruit spot.

PLATE 7.

FIG. 1. Conidia from a pustule such as is shown in FIG. 3, PLATE 32.

FIG. 2. Spore production in solution A agar after four days.

FIG. 3. Chlamydospores from an old culture.

FIG. 4. Germinating chlamydospores.

FIG. 5. Olive-brown hyphae from a six week's old liquid culture after one day in a Van Tieghem cell.

FIG. 6. A similar hypha after two days in a Van Tieghem cell.

FIG. 7. A sketch of a portion of the vascular system of an apple.

APPLE LEAF SPOT.

ISAAC M. LEWIS.

The disease known as "leaf-spot" or brown spot of apple leaves is of general occurrence throughout the entire state of New Hampshire and its importance as an agent of destruction has doubtless been greatly underestimated. The disease first makes its appearance on the young leaves shortly after they unfold from the bud in the early spring and may be readily recognized by the presence of small purple areas which, as growth progresses, reach a diameter of from one-eighth to one-half inch. The spots are quite uniformly circular in outline and the color soon

changes to a yellowish brown. The margins are somewhat elevated, giving to the spot a sunken appearance. (Fig. 1, Plate 9.) The infection spreads throughout the spring and early summer and in many cases the leaf becomes densely covered with spots; each spot retaining about the same size and color until mid-summer. As the spots grow older, secondary growth takes place from the central affected area and a somewhat irregular blotch is formed in which the outline of the original spot can always be recognized. It often happens that several of these areas become confluent and thus the greater part of the leaf may become affected (Fig. 2, Plate 9.) The color of these older areas is generally somewhat grayish. Leaves so affected fall from the trees much earlier than under normal conditions and their working efficiency is always greatly reduced by the middle of the summer, the season at which they should be most active in supplying food for ripening the fruit and developing the buds for the succeeding year. Trees so robbed of their foliage from year to year, must eventually become greatly impaired in their vigor and finally succumb to premature destruction.

Cause of Leaf-Spot.

The cause of leaf-spot has occasioned no little difficulty and while it seems quite probable that different investigators have been dealing with the same spot various conflicting accounts have been offered as to its cause. The majority of investigators since 1892, the time at which the disease was first reported from Virginia by Alwood, basing their conclusions rather on the the ease with which the disease is controlled by spraying than by careful inoculation experiments, have regarded the disease as of fungous origin. In this opinion, however, all investigators have not concurred. Stewart and Eustace regarded the spots as due to atmospheric influences, or spray injuries and gave it as their opinion that the various fungi present in the affected tissue were saprophytes and not primarily concerned with causing the disease. Stone and Smith 1903 regarded frost as the primary agency in the cause of spots as they occurred in Massachusetts. These explanations of the non-fungous origin of the disease are brought strongly into question by the results of various spray experiments conducted during the progress of this investigation and cited in a later paragraph.

The investigators who have decided in favor of the fungous origin of the disturbance have not agreed as to the specific fungus which is of primary importance in its cause. This difficulty is

occasioned by the fact that no one fungus is found to fruit consistently and to the exclusion of others on the affected areas.

Lamson in 1899 decided that the fungus *Phyllosticta pirina* caused the "brown spot" of apple leaves in New Hampshire and Corbett reached a similar conclusion in West Virginia.

Other investigators have reported the disease as being caused primarily by *Phyllosticta limitata*, while still others regard *Sphaeropsis Malorum* Berk. as the specified cause.

Doubtless the most comprehensive piece of research attempted to determine the exact fungus responsible for the infection was that carried on by Scott and Rorer in connection with demonstration spraying work in the Ozarks in 1907. They found that contrary to general belief the fungus *Sphaeropsis malorum* is the cause of the disease that occurs throughout the middle west. The other fungi which are found to fruit on the affected areas they regard as Saprophytes, which are of only secondary importance.

The number of fungi reported as fruiting on these spots has been increased during the past year by Hartley of Minnesota and others. A complete list of the species reported embraces the following species: *Coryneum foliicolum*, *Coniothyrium pirina*, *Sphaeropsis Malorum*, *Monochoetia Mali*, *Pestalozzia brevisita*, *Phyllosticta limitata*, *Phoma mali*, *Septoria piricola*, and undetermined species of *Phyllosticta*, *.Metosphaeria*, and one of the *Tuberculariae*.

The fungus *Coniothyrium pirina* which was recently transferred from the genus *Phyllosticta* by Sheldon, was tested thoroughly by Hartley to determine whether or not it may act as a parasite. He concludes from the result of many inoculations under varying conditions, that the fungus is "merely a facultative parasite and does not cause the serious defoliation of apple trees which have been attributed to it." The same results were obtained by Hartley in experimental inoculations with pure cultures of *Coryneum follicolum*.

Believing that the exact relation of all the fungi associated with the spots had not been thoroughly tested, an investigation was begun during the past summer to determine, if possible, the cause of the disease as it occurs in this state, and means of control by various spray mixtures.

Spots of various stages of development were taken from the leaves and by means of the poured plate method different species of fungi fruiting on them were isolated into pure cultures. The medium used for these cultures was beet agar, a medium

on which all of the fungi isolated grew well and produced an abundance of spores. Cultures were also secured by the slant agar tube method used by Scott and Rorer. Each method proved easy of manipulation and about equally effective.

The species of fungi which were found to predominate were *Coniothprium pirina, Coryneum foliicolum, Sphaeropsis maiorum, Altenaria* sp. and one of the *Tuberculariae.* Occasionally other spores were met on making examinations of the spots but they were not isolated into culture. The number so isolated could doubtless have been materially increased. However, no other spore occurred abundantly enough to warrant the supposition that they were of primary importance in causing the spots.

The growths from many different spots yielded pure cultures of *Sphaeropsis malorum* and this was quite generally true, as pointed out by Scott and Rorer, when the spots taken for the cultures were still young and purple. From other spots pure cultures of *Coniothyrium pirina* were secured and the pycnidia of this fungus occurred more abundantly on the affected areas than any other.

In order to test the parasitic nature of the different fungi, various inoculations were made. Spores grown in pure cultures were placed in sterile distilled water and sprayed abundantly upon the upper and lower surfaces of clean, spot free leaves of young shoots of the trees growing in the station orchard. These inoculations were made always in the evening between five and six o'clock. The first of the series was made Aug. 1 and three other attempts were made later. Check branches were sprayed with distilled water. On none of the inoculated branches could a decided increase in the number of spots be detected. There were scarcely any new spots developed at this time from natural infection and many of the inoculations, as well as the checks, remained perfectly free, showing that the period at which the leaf is naturally infected is earlier in the spring and summer.

All of the fungi isolated have been kept growing in pure culture and it is hoped to test them still further on young seedlings and nursery stock in the greenhouse, and again in the orchard next season. As a result of this season's inoculation experiments it is impossible to offer more than negative results as to the cause of the spots. I am of the opinion, however, that the fungus *Sphaeropsis malorum* which is known to cause canker of apple limbs and is an active parasite, will be found to be the primary cause of apple leaf spot. This supposition must, how-

FIG. 1. Unsprayed tree defoliated by Leaf Spot.

FIG. 2. Sprayed tree adjacent to the above.

FIG. 1. Early Stage of Leaf Spot.

FIG. 2. Late Stage of Leaf Spot, showing growth in the size of the spots.

FIG. 3. Scab fungus as seen on the foliage.

ever, be supported by direct experiment before it can be definitely affirmed for the spots considered in this investigation.

Treatment.

Leaf spot is very readily controlled by spraying. The methods used in preventing scab or other fungus diseases are sufficient to keep the leaf spots under control. During the past season spraying experiments were carried on with young orchard trees of McIntosh, various spray mixtures being used. (See page 385).

The following table shows the results obtained from the several mixtures. It will be noted that on the unsprayed plots practically all of the leaves were spotted, while on some of the sprayed plots the per cent. was as low as eighteen. The number of spots on individual leaves taken from unsprayed trees was many times as great as ones from the sprayed plots, and had the number of spots per one hundred leaves been taken, the results in the table would have been still more striking. The trees were sprayed five times during the season but it is not probable that the fourth and fifth spraying had any decided effect on this disease. The first spraying was made May 15, and this was followed by four others on the following dates: May 27, June 10, June 18, July 30. A careful estimate of the per cent. of spotted leaves on the various plots is given in the following table:

Fungicide	Per cent Spotted
None	97%
Lime sulfur 9-6-50	21
None	95
Lime sulfur 2-1-50	18
" " Thomsen 1-25	26
" " 15-10-50	21
" " Niagara 1-50	33
Bordeaux 3-3-50	26
" Eagle 1-24	26
" 4-4-50	30

The leaves on the sprayed plots remained on the trees long after the unsprayed plots were completely defoliated. (Compare Pl. 8, Fig. 1 with Fig. 2).

It is not necessary to use special spray mixtures to combat this disease for as is shown above, the mixtures used in controlling the fungous diseases of the fruit will also prevent the "leaf-spot."

ever, be supported by direct experiment before it can be definitely affirmed for the spots considered in this investigation.

Treatment.

Leaf spot is very readily controlled by spraying. The methods used in preventing scab or other fungus diseases are sufficient to keep the leaf spots under control. During the past season spraying experiments were carried on with young orchard trees of McIntosh, various spray mixtures being used. (See page 385).

The following table shows the results obtained from the several mixtures. It will be noted that on the unsprayed plots practically all of the leaves were spotted, while on some of the sprayed plots the per cent. was as low as eighteen. The number of spots on individual leaves taken from unsprayed trees was many times as great as ones from the sprayed plots, and had the number of spots per one hundred leaves been taken, the results in the table would have been still more striking. The trees were sprayed five times during the season but it is not probable that the fourth and fifth spraying had any decided effect on this disease. The first spraying was made May 15, and this was followed by four others on the following dates: May 27, June 10, June 18, July 30. A careful estimate of the per cent. of spotted leaves on the various plots is given in the following table:

Fungicide	Per cent Spotted
None	97%
Lime sulfur 9-6-50	21
None	95
Lime sulfur 2-1-50	18
" " Thomsen 1-25	26
" " 15-10-50	21
" " Niagara 1-50	33
Bordeaux 3-3-50	26
" Eagle 1-24	26
" 4-4-50	30

The leaves on the sprayed plots remained on the trees long after the unsprayed plots were completely defoliated. (Compare Pl. 8, Fig. 1 with Fig. 2).

It is not necessary to use special spray mixtures to combat this disease for as is shown above, the mixtures used in controlling the fungous diseases of the fruit will also prevent the "leaf-spot."

PINE BLIGHT.

Much anxiety has been caused in New Hampshire in the past two years by the so-called "pine blight." The trouble has occurred chiefly on the white pine, *Pinus Strobus*. It has not been confined to New Hampshire but is widely distributed over New England and occurred in Pennsylvania and New York. It appears as a browning of the needles, which is fairly uniform over the entire tree. In some cases the tip of the needle is brown, while the base is green, and apparently normal. Such a condition is probably the result of frost after the needle had begun its development in the spring. The pine needle grows from the base, and it is thus possible for the tip to be injured by frost when young, and the better protected base remain uninjured and continue the development of the needle.

In other cases, the browning does not seem to be so definitely limited to the tip of the needle, but apparently spreads to the base as the season advances. In such cases, the otherwise green portion of the needle is often covered with yellowish spots. This condition cannot be attributed entirely to the frost and would suggest that the trouble might be the result of a parasitic fungus. Various experiments have been made to test this hypothesis, and while fungi are sometimes present, thus far, no fungus has been isolated from these affected needles that seems likely to prove to be the responsible agency.

A disease which affects the whole tree so uniformly might be expected to have its cause in the roots or trunk. Many trees have been dug up, and a thorough gross and microscopic examination made with this point in view. No evidence of insects or fungi have been found, and the roots and trunk of the diseased trees appear normal.

The only other possible explanation of the disease is that it is a physiological trouble resulting from drought, unfavorable location, or similar causes. In order to determine the probable effect of location and drought, a careful study has been made of the conditions existing in several different sections of the state where the trouble was most serious. Notes were taken on depth and nature of the soil, drainage, exposure, surrounding vegetation, extent of the disease, etc. The results thus far obtained indicate that a large per cent. of the injured trees are in worn out pastures and in sandy soil. Such trees would be favorably situated to receive the full effects of the droughts of the past two summers. When we recall that the pine is an extremely shallow-

rooted tree, it seems quite probable that much of the trouble has been due to dry weather.

As a means of determining whether the disease increased from year to year all of the trees, in two different pastures, that were affected in 1907 were located, and a description made of the condition of each tree. Notes taken late in 1908 showed that the disease had not spread to other trees. In some cases the new needles on the affected trees turned brown in the same manner as those of the previous year. This might be accounted for by the greatly weakened condition of the tree, resulting from the trouble of 1907, but more probably was partly due to the repeated droughts of the past summer.

The "pine blight" is evidently not a contagious disease and there seems to be no reason to expect marked development of the trouble.

NOTES ON APPLE DISEASES.

Apple Scab, *Venturia Pomi* (Fr.) Wint.

This disease was very serious in the summer of 1907 and did marked damage the past season. The greater prevalence of scab in the former season is probably due to the warm, dry weather of the past summer; the spread and development of the fungus being greatly favored by moisture.

Appearance. The disease produces serious results on both foliage and fruit. It attacks the leaves soon after they have unfolded in the spring and early in June it is quite evident on the foliage as circular, olive colored patches. See Fig. 3, Plate 9. These colonies produce large number of spores and serve as a source of infection for the fruit. The fungus greatly decreases the vitality of the leaf, usually causing it to fall prematurely. As a result of the disease trees are often practically defoliated long before the fruit is mature.

The most serious and most familiar results, however, are produced on the fruit. The effects found here are known among commercial apple men as "scab," "fungus" or "black spot." Circular spots one-eight to one-half inch in diameter are produced. They are olive in color and in later stages are often surrounded by a narrow border of light gray. The scab colonies develop vigorously on the young fruit but later in the season the growth becomes very slow. The majority of the infections are made early in the season but a second spread of the disease often occurs in August. Its results are indicated by the numerous apparently young colonies on the fruit at gathering time.

Some of these are so small as to be readily overlooked, but may later make marked development in cellar storage.

Development in Storage. During the winter of 1907-8 much trouble was experienced with scab in the Boston cold storage plants, and great losses were met by commission merchants from this cause. Various specimens of the disease were sent to this station for identification. At first sight one familiar with the disease, as seen in the orchard, would be inclined to call the storage trouble a separate and distinct disease. The fungus made an unusual development beneath the cuticle before breaking through and the mycelium was very dark in color. As a result of this, sunken black spots developed on the apple that might attain a diameter of one-fourth inch, before any break was made in the skin. See Figs. 1 and 2, Plate 10. Later the cuticle was ruptured and the usual forms of spore and sporophore exposed. See Fig. 3, Plate 10. It does not seem probable that the disease could have spread through the cold storage building. It is very much more plausible to assume that the scab developed from very small colonies that were overlooked at the time of storage, or else from spores that were on the apples at that time. In cases where the apples were barrelled several days before reaching the storage plant it is very probable that the disease made rapid development during that time. The following fact furnishes strong evidence in support of this statement. In the fall of 1908 a barrel of perfect McIntosh apples was picked from unsprayed trees and a barrel from trees sprayed late in the season and the two placed in cellar storage. In two weeks the unsprayed apples were found to be badly scabbed while those that had been sprayed were still comparatively free from the disease. The spots must have developed from colonies that were not noticeable at the time of gathering, or else from spores lodged on the apples. There is no doubt but what there is much greater benefit derived from late sprayings for scab than is usually evident at the time of gathering.

Treatment. The disease can be controlled by spraying. The first application should be made as soon as the leaves unfold; the second, just after the blossoms have fallen; the third, two or three weeks later, and the fourth four or five weeks before gathering time. The first and second sprayings are especially important and should be very thorough. For further information in regard to treatment, see discussion under fungicides, pages 382-389.

Sooty Blotch. *Phyllachora pomigena.* [(Schw.) Sacc.]

This disease produces sooty blotches on the surface of the apple that seriously mar the appearance of the fruit and may later affect its keeping qualities. See Fig. 2, Plate 11. The varieties having a light-colored skin are damaged most in appearance. The fungous growth is on the surface of the fruit and hence its development is greatly favored by moist weather.

Treatment. The disease is readily controlled by spraying as for scab. Thorough pruning is very important and if light and air have full access to the fruit the disease usually gives little trouble.

Apple Rust. *Gymnosporangium* Spp.

Distribution. Apple rust is very widely distributed and in some sections quite injurious. It occurs abundantly throughout New Hampshire and while by no means one of the most serious apple troubles, it doubtless causes considerable damage. This disease occurs wherever apple trees and cedars are growing in close proximity.

Appearance of the Disease. The rust affects the leaves of the apple trees, causing yellowish spots, which often become somewhat thickened and in which are located the spore-bearing organs of the fungus. (Fig. 1, Plate 11). These spots appear on the leaves in May and June. The spores, which are produced in great numbers, are borne by the wind and attack the twigs of cedar trees, causing morbid growths or swellings, the so-called "cedar apples." (Fig 3, Plate 11). The fungus passes the winter in the tissue of the "cedar apple" and in the spring produces an abundance of spores in the gelatinous outgrowths of these galls. These spores, when borne back to the apple trees, set up the infection again and thus the fungus passes from one host back to the other.

Treatment. Spraying experiments have not proven satisfactory in controlling this disease, and since the "cedar apple" harbors the disease through the winter the method of control is obviously to destroy them, or, when practicable, the cedar trees themselves. This is at present the only effective method known.

European Apple Tree Canker. *Nectria ditissima* [Tul.]

Under ordinary conditions wounds on trees are healed over in course of time as a result of the activity of the adjacent living tissue. It is a common sight in the orchards of New Hamp-

shire to find wounds which have not healed over, sometimes even after the repeated attempts of several years. Such injured places are usually prevented from healing, and in some cases may be originally caused by the presence of a foreign organism. These wounds are commonly known as "cankers." In the twenty-eighth report, two cankers common on New Hampshire apple trees were described, one the Illinois Apple-tree Canker and the other the New York or Black Rot Canker. Since that time a third "canker" has been identified. This disease has long been known as a serious disease of the apple trees in Europe and hence is called the "European Apple-tree Canker." It is of widespread occurrence in the orchards of the state and has the characteristic appearance shown in Fig. 4, Plate 10. The series of ridges around the wound is due to repeated attempts to heal. The canker is caused by the presence of the fungus *Nectria ditissima.* Its mycelium spreads into the new growth as it attempts to cover the wound, killing it and thus enlarging the canker. In the fall of the year the mycelium of the fungus produces minute conidia. The following spring red lemon-shaped perithecia break through the bark in compact patches. These may be seen with the naked eye. They contain numerous two-celled spores borne in asci or sacs. These spores and the conidia are the agencies for spreading the disease.

Treatment. Cankered limbs should be cut out and *burned.* All wounds should be thoroughly coated with paint or tar.

WINTER INJURY.

The winter of 1906-07 caused very serious injury in the orchards of New Hampshire. The damage was especially great in young orchards and in those situated on low ground. Many trees were found to be entirely dead the next spring and many others had only sufficient vitality to put forth leaves on a few isolated limbs. (See Fig. 4, Plate 10). Upon examination of the inner bark of the injured trees and limbs, it was found to be brown and apparently dead. As the summer advanced it was evident that many trees that had appeared fairly vigorous early in the spring had sustained serious injury. The leaves on one large limb after another would wither and turn brown. It was found in such cases that the cambium had been dead over large areas from the first of the season and that the limb was practically girdled. Throughout the summer of 1907, and even in that of 1908, trees continued to succumb to the injuries received in the above mentioned winter. On these trees and also on others that

survived sunken, dead areas of bark were common. (Plates 12 and 13.) These became quite noticeable by the middle of the summer of 1907, and on the trees that lived, continued to become more prominent. The living tissue at the margin of these dead patches made more than normal growth, pushing out over the injury and developing a marked ridge around it, thus leaving it as a conspicuously depressed area. The line between the living and dead bark was often marked by an open crack.

Various varieties of trees suffered from winter injury but the Baldwin seemed to have been far more susceptible than any other variety of apple. The large number of cases of serious injury to the Baldwins was probably due, in part, to the preponderance of Baldwin trees in the state, but this does not seem to be the whole explanation.

Cause of the Winter Injury. The winter of 1906-7 was an unusually cold one and the low temperatures recorded might be regarded as sufficient explanation, in themselves, for the serious injury. Injury from cold in plants, however, is largely dependent upon the condition of the cells exposed. The condition in which the apple trees went into the winter is a very important consideration. The fall of 1906 was characterized by the frequency of showers and unusually high temperatures. As a result of this, growth continued late in the season and the trees went into the winter without the usual reduction in amount of water, and with the wood not completely matured. This must have been especially true of vigorous growing varieties like the Baldwin, and of trees situated on low ground and in poorly drained soil. The growing tissue of these trees must have gone into the winter in an immature and water-gorged condition that was most unfavorable for withstanding the cold weather that came on early in the winter. The apple crop in 1906 was large and the vitality of the trees greatly reduced from this source. An additional cause for the serious results of the following winter are to be found in this overproduction of the previous season.

Spray Injury.

Spraying experiments conducted in New Hampshire orchards for the past three years have shown conclusively that injury from Bordeaux mixture is not of uncommon occurrence. It appears on the fruit first as small, round, black or brown specks scattered thickly over the surface of the apple. As the fruit matures the skin takes on a corky and russeted surface, that greatly mars its appearance. In serious cases the fruit may be

much roughened and deformed and sometimes large sunken scars appear on its surface. Such fruit often drops from the tree early in the season and in no case is it of any value for commercial or storage purposes.

On the foliage, brown, circular spots two or three millimeters in diameter are produced. These bear a very close resemblance to the leaf spot previously described. Soon after the appearance of the spots the leaves may begin to turn yellow and die. Leaves so affected soon fall and in serious cases the trees may be almost entirely defoliated. Such instances, however, are rare.

The most serious injuries have been obtained from sprayings made a few weeks after the blossoms fall. Sprayings made in August or late in July have done little or no damage. In all cases of bordeaux injury the sprayings was followed within the next few days by a rain storm. The experiments of the past three years have shown that the Baldwin apple is more susceptible to injury from Bordeaux than the McIntosh. For further discussion, see Fungicides, pages 382-389.

NOTES ON PEACH DISEASES.

Peach Yellows.

History and Distribution. The Yellows is an American disease of the peach and allied fruits. It has been known for over one hundred years, and is widely distributed throughout the states east of the Mississippi and north of the northern boundary of Tennessee and North Carolina. It is most abundant in Delaware, Maryland, New Jersey, New York, Connecticut, Michigan, Pennsylvania and is doubtless spreading slowly to other states. Yellows had not been definitely reported from New Hampshire until the summer of 1908.

The writer is not aware of how general its distribution throughout the states will prove to be, but peach growers are warned to keep a vigilant watch over their orchards as the disease is known to occur within the boundaries of the state. Like tuberculosis in the human race, Yellows is the most dreaded disease to which the peach is subject, for when a tree once becomes affected with this disease certain death is the result.

Symptoms of Yellows. The term Yellows as applied to the disease is in a measure unfortunate, since people are often caused to regard yellowness of the tree as one of the first and indisputable symptoms of the disease. This, however, is not always true. Many peach orchards which the inexperienced observer believes to be suffering from Yellows, are but in ad-

Fig. 1. Scab on apple from cold storage.

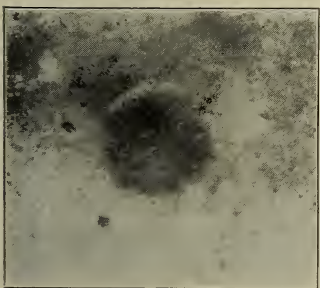


Fig. 2. Early stage of scab on cold storage apple.

Fig. 3. Later stages of scab on cold storage apple.

Fig. 4. European apple-tree canker.

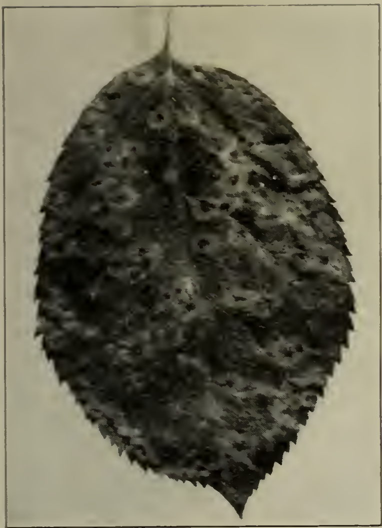
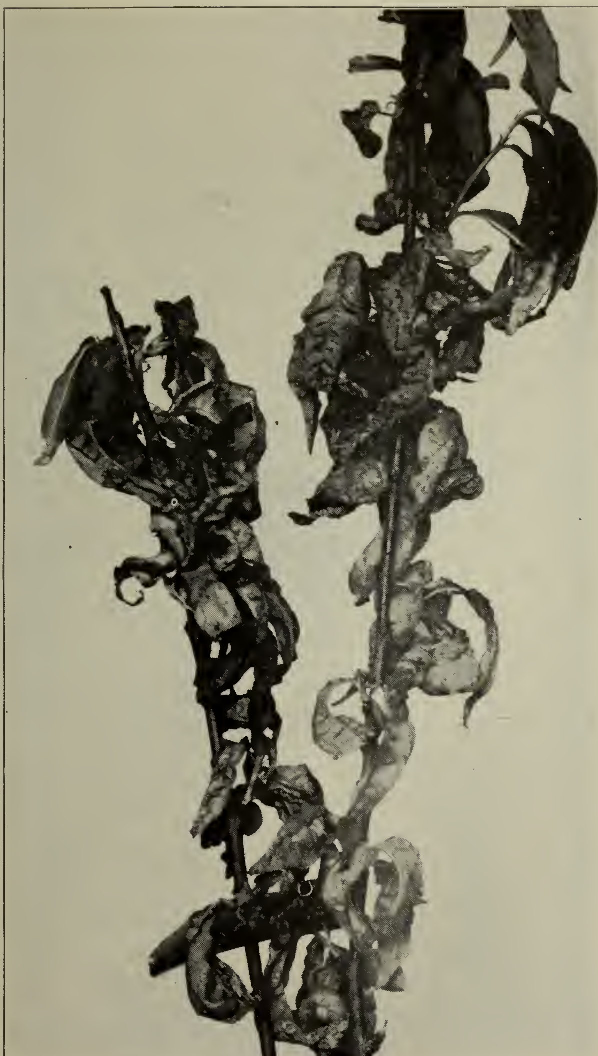


FIG. 1. Rust on apple leaf.

FIG. 2. "Sooty Blotch" of apple.

FIG. 3. Cedar Apple on Red Cedar.

Winter Injury on a young apple tree.



Peach Leaf Curl.

Baldwin apples russetted with Bordeaux mixture in 1906.

vanced stages of other diseased conditions brought on by lack of proper pruning, fertilizing and precaution against borers and insect pests. The leaf curl has also been mistaken for yellows although the symptoms are quite different.

Yellows is a definite disease fatal and communicable and in many states amenable to the police powers of the commonwealth. The symptoms of yellows when once learned are so characteristic that there is little danger of confusing them with the symptoms of borers, neglect or drought. In bearing trees the first indication of the presence of Yellows is the premature ripening of the fruit. This may occur from one to six weeks earlier than the normal time of ripening. These prematurely ripened fruits are unmistakably characterized by the presence of bright red

(a) (b)

FIG. 15. Peach yellows, (*a*) showing the spotted appearance of the fruit, and (b) the streaks in the flesh. (After L. H. Bailey).

blotches and the flesh is often more or less marked with red spots and streaks which extend from the surface to the pit. (Fig. 15). The mere prematureness of ripening is not, however, conclusive proof of the presence of Yellows. It is the presence of the red blotches and streaks on such prematurely ripened fruits. It often happens that during the first year of the disease this kind of fruit is restricted to particular limbs or even to single twigs which, however, do not differ in appearance from other limbs of the tree.

In the second year, the disease spreads to other parts of the tree, even if the diseased branches have been removed. Addi-

tional symptoms also begin to be manifest, chief among which may be mentioned the development of winter buds out of their normal season and the growth of feeble twiggy and much branched shoots on the main branches and even on the trunk. The premature expanding of buds may be seen most clearly in the fall after the tree has lost its leaves. These shoots rarely grow more than three or four inches long.

The leaves upon them are small and narrow, yellowish and they stand out stiffly from the stem, contrasting strongly with the drooping healthy leaves below them. (Fig. 16). It occasionally happens that the blossoms of the diseased shoots open in the fall.

FIG. 16. Yellows "tip" appearing late in October. (After L. H. Bailey.)

The third symptom is the growth of shoots from adventitious or resting buds on the trunk and larger branches. The leaves upon these shoots are quite long and narrow, yellow in color and some of the larger "water sprouts" develop broom-like clusters of branches which have pale green, slender leaves. Fig. 17.

In late stages of yellows the tree has a general stunted appearance. The leaves are all of a reddish or yellowish color and are greatly reduced in size. Trees in this condition might be confused with those suffering from some lack of vigor brought on by other causes. In distinguishing Yellows the above peculiarities of growth and development must be used rather than the notion of yellow color. Trees which show these characters — premature ripening of fruit; fruit spotted and blotched with red; twiggy clustered shoots bearing small yellow foliage, may be considered as certainly affected with Yellows.

Cause and Spread. Yellows is a contagious disease. It is spread from tree to tree and sooner or later every tree in an orchard or even the entire community in which the disease appears may be expected to die unless precautions are taken to keep it in check. It is not known how Yellows spreads.

FIG. 17. Yellows tuft—1-2 nat. size. (After Bailey).

There appears to be no specific germ associated with it. The disease is not spread through the soil, for young trees set where Yellows trees have been removed are no more liable to contract the disease than are the trees which are some distance away. This has been amply demonstrated in the peach growing section of Michigan. It is not spread from flower to flower for many trees contract the disease that have never blossomed. It is not inherent in the roots, for trees grafted upon plum stocks often contract the disease. Briefly it may be said that almost every origin which has been ascribed for the disease has been shown untenable.

Although the cause of Yellows is unknown, it has been clearly shown in many districts that if affected trees are permitted to live, the disease spreads to other trees. Cases are cited in which affected trees which have been cut down and left in the orchard have spread the disease. Dragging uprooted, diseased trees through the orchard is known to spread the infection. The disease has doubtless gained entrance into many sections through nursery stock.

Prevention and Control. With the present knowledge of the disease its cure seems impossible. Thus far the only successful measures employed in combating it have been of a preventive nature. There being no germ or insect pest associated with the disease, the attempts to control it by spraying have proven futile. Experiments with different fertilizers have been of no avail. *Whenever a tree becomes affected with this most subtle of all diseases its final death is inevitable.* The contagion and spread being as explained above, the remedy suggests itself—removal of the source of contagion. Practice has shown this to be the only effective method. Yellows is prevented by the removal of all affected trees *root* and *branch* and their subsequent destruction by fire as near the point of removal as practicable. In order to keep the stand of the orchard, young trees may be planted in the same place the following spring. Experience has shown that there is a rather less tendency for these trees to contract yellows than is the case with adjacent trees. This method alone has proved sufficient to stem the tide of invasion which at one time threatened to destroy the peach raising industry in some of the best peach districts. Its success depends in a large measure on the co-operation of all the owners of peach orchards for one or two affected orchards in a community if not properly treated are sufficient to continually spread the disease.

Leaf Curl of Peach. *(Exoascus deformans.* Burk.*)*

The disease of the peach known as leaf curl, is very widely distributed. It is found practically wherever the peach is cultivated and aside from yellows is one of the most serious diseases to which it is subject. Pierce gives as an estimate of the total losses in the United States in a single year from this source alone, the sum of $3,000,000.

Appearance of the Disease. This disease affects only the leaves and twigs of the peach, and the twigs are not usually attacked in a manner serious enough to attract attention. The effect on the leaves, is, however, very striking and is quite easily recognized. The leaves often show the characteristic appearance of the disease at the time they emerge from the bud. A roughened surface and an excess of coloring are the first symptoms manifest. As the young leaves quickly grow to their normal size, the affected part is thrown into a series of irregular folds which frequently run transversely to the long axis of the leaf. It often happens that the distortions draw the edges of the leaf together in such a way that it presents an appearance of being inflated. (Plate 14.) The entire leaf or only a part of it may become affected. In mature leaves the color may become somewhat reddish, but the green color is usually lost and the leaf is characterized by a pale discoloration. Such affected leaves soon fall off and in severe cases the tree may be entirely defoliated and normal growth seriously checked. Bearing trees lose their fruit for the season and it not infrequently happens that no fruit buds are formed for the next year, thus resulting in a loss of two crops. After the affected leaves have fallen, dormant buds often develop, and the tree makes an attempt to supply itself with new and healthy foliage. This second crop of leaves is rarely attacked by the curl.

Cause of the Disease. The curl of peach leaves is caused by the fungus *Exoascus deformans*, which lives through the winter in the buds and affected branches and continues its growth along with the young leaves in the spring. The spores of the fungus are produced in short, erect growths of a sac-like nature and each sac contains eight spores. It is these numerous sacs or asci which give to the affected leaves the somewhat mealy appearance. These spores are very small and light and easily borne about by the wind. Whenever they fall upon the susceptible parts of another tree, they grow into its tissue and so cause the disease. Doubtless many of the spores live through

the winter, either on the tree or on the ground, and help spread the infection in the spring.

Treatment. Since the fungus passes through the winter in the form of a mycelium in the twigs and buds it will be readily seen that attempts to control the disease by spraying cannot be entirely successful the first year. Leaf curl may, however, be effectively controlled by:

1. Spraying with Bordeaux just previous to the opening ot the buds in the spring. This spraying is *very important.*

2. Spraying again with weak Bordeaux as soon as the blossoms have fallen. This prevents infection from spores that have wintered over on trees or on the ground.

3. Spraying again with weak Bordeaux when the affected leaves begin to manifest the mealy appearance. This prevents summer infection of leaves and of the buds for the succeeding year.

Fungicides.

In view of the fact that it had been repeatedly demonstrated in New Hampshire orchards that home made Bordeaux may cause injury to the fruit and foliage, (page 375) it was important to determine, as far as possible, the cause of this and also to find some means of obviating the trouble.

Cause of Bordeaux Injury. Extensive studies have been made on the first point in the experiment stations of Illinois, New York, and other states, without any satisfactory conclusion being reached. The problem has been under observation at the New Hampshire station for several years and efforts have been made to determine the cause, but without any great success. Attempts have been made to produce the trouble artificially, but have given only negative results. The chemists of the stations have made studies of the chemical nature of bordeaux and of its probable reactions as exposed on the tree, but the work has not yet been brought to a conclusion. It is not possible with our present knowledge of the matter to give a complete explanation of the cause, but our observations agree with those from other stations, that the atmospheric conditions may greatly modify the action of the bordeaux; injury to the fruit and foliage usually resulting from the effects of a rain storm soon after spraying. The washing out of the excess lime by this means is a probable explanation for a large part of the injury.

Experiments with Bordeaux Mixture. A constantly increasing number of prepared bordeauxs are on the market and are being

extensively bought by the public. Many of the agents for these claim their product to contain great fungicidal value combined with freedom from injury to the foliage and fruit. It was decided to test the value of a number of these, as compared with various home-made mixtures. If results were to be obtained in a few years it was advisable to test these on plants which were practically certain to be diseased. The McIntosh apple scarcely ever escapes the work of the scab and was therefore a desirable tree to work with. In the spring of 1907, arrangements were made with Arthur Ladd and Jonathan Smith of Deerfield for carrying on such experiments in their McIntosh orchards.

The proprietary mixtures used were Leggett's Dry Bordeaux and Leggett's Oxidized Dry Bordeaux sold by Leggett & Brother of New York; Target Quick Bordeaux and Target Standard Bordeaux, sold by the American Horticultural Distributing Co., of Martinsburg, W. Va.; Eagle Bordeaux sold by the Adler Color & Chemical Works of New York; French Bordeaux, sold by Hammond's Slug Shot Works, Fishkill-on-Hudson, New York; Lenox Bordeaux, from Lenox Sprayer and Chemical Co., Pittsfield, Mass.; Lion Bordeaux, from the James A. Blanchard Co., New York; Fairmount Bordeaux, from the Fairmount Chemical Laboratories of Philadelphia, Pa.; and Pyrox from the Bowker Insecticide Co., Boston. All of these except the first three, are paste bordeauxs. The Target Quick Bordeaux consists of a bag of fine pulverized copper sulfate and another of finely ground lime which are to be hung in a barrel of water to dissolve, thus producing a mixture very similar to home-made bordeaux. All of the proprietary mixtures were made up as directed on the package.

Along with these proprietary mixtures was used copper phosphate, home-made bordeauxs and benzoate of soda bordeaux. In describing a bordeaux the number of pounds of copper sulfate is given before that of lime, thus a 2-4-50 bordeaux contained 2 pounds of copper sulfate and four of lime to fifty gallons. The sodium benzoate of plots 18 and 20 was prepared by combining the copper sulfate and benzoate of soda before the addition of the lime and that in plot 19 was made by adding the benzoate of soda solution to already prepared bordeaux. One-half pound of sodium benzoate was used to fifty gallons ot the mixture.

Each plot consisted of five or more trees. The first spraying was made May 17, the second June 7 as the blossoms were falling, the third June 21. The first spraying was omitted on plots

19 and 20. Notes were taken on the drops August 1, August 27, and October 1. The apples were gathered the first week in October. Any apple having even a small scab spot was considered scabbed. The results given below are estimated on total dropped and picked fruit:

Plot.	Fungicide.	Percentage Scabbed
	LADD ORCHARD.	
1.	Bordeaux, Lenox	79.9
2.	Bordeaux, Target Quick	67.7
3.	Bordeaux, Standard	63.9
4.	Bordeaux, Leggett's	82.8
5.	Bordeaux, Leggett's Oxidized	83.4
6.	Bordeaux, Eagle	68.8
7.	Bordeaux, French	64.4
8.	Bordeaux, Lion	90.9
9.	Bordeaux, Fairmount	95.0
10.	Copper phosphate 15 lbs. to 50 gal	82.2
11.	Bordeaux, 3-4-50	57.1
12.	Bordeaux, Pyrox	81.0
13.	Bordeaux, 2-4-50	73.0
14.	None	86.0
	SMITH ORCHARD.	
15.	Bordeaux, 4-4-50	53.8
16.	Bordeaux, 3-4-50	52.1
17.	Bordeaux, 2-4-50	66.0
18.	Bordeaux, Sod Benz. 1-1-½-50	70.4
19.	Bordeaux, Sod Benz. 1-1-½-50	81.7
20.	Bordeaux, Sod Benz. 1-1-½-50	90.7
21.	None	93.9

The greater percentage of scab on plot 20 than on 18 indicates the value of the first spraying. The large percentage of scab on the orchards, as a whole, is partly due to a late spread of the disease from the unsprayed plots and from those sprayed with inefficient mixture to other parts of the orchard. This was shown by the large number of young scab spots on the apples at the time of gathering and also by notes taken on development of the disease at various times during the season. The contrast in the results is therefore not so great as the probable contrast in fungicidal value of the mixtures.

Chemical Analyses. A chemical analysis was made by the station chemists, of the various bordeauxs used in the experiments. The first three columns below give the result of the analysis of a sample of the prepared package as placed on the market. In the third and fourth columns are given the number of pounds of copper sulfate and of lime that a fifty gallon barrel

of the mixture would contain, if made according to the directions furnished by the company.

Fungicide.	Water.	Copper Oxide.	Calcium Oxide.	Copper Sulfate per barrel.	Lime per bbl.
Pyrox	65.2	2.22	3.00	.35	.15
Lenox	67.87	1.54	17.76	.49	1.78
Lion	80.00	3.12	9.70	1.00	.97
French	81.6	3.13	4.54	2.00	.91
Grassellis	50.19	7.32	22.99	2.34	2.30
Fairmount	50.0	7.65	12.35	2.45	1.24
Standard	63.0	4.81	15.35	3.08	3.07
Target Quick				4.00	6.00
Eagle	54.1	6.7	11.56	4.29	2.31
Leggett's blue	4.0	13.73	41.28	4.39	4.13
Leggett's oxidized	7.3	17.8	27.6	5.70	2.76

Tests were not made to determine what other ingredients than copper and calcium compounds might be present. The first three as given above do not have more copper than a 1-3-50 Bordeaux, and the results obtained show their effectiveness to be in keeping with their strength. The next two do not vary far from a 2-4-50 bordeaux, either in strength or in results. The Fairmount paste was in bad mechanical condition and might håve given better results if the solution had been made in hot water or had been allowed to stand over night before using. No such directions were given on the package, however. As used, many large crystals of copper sulfate were taken out in passing the liquid through the sieve. It will be noticed that several of the mixtures have three and four pounds of copper as sulfate to the barrel. Of these, the paste bordeauxs were quite effective but not so much so as the home-made bordeaux of equal strength. The dry bordeaux and the so-called copper phosphate were entirely unsatisfactory as fungicides in spite of the large amount of copper present. In addition to this they produced decided injury to the foliage. This was especially true of the oxidized Leggett mixture. Slight injury of the foliage was also found on the plot sprayed with Eagle bordeaux and with the copper phosphate. No injury was found on the trees treated with the home-made mixture, even when used in the 4-4-50 strength. The results show that the home-made Bordeaux is a more satisfactory mixture than any of the proprietary preparations, and that the 3-3-50 formula is the weakest solution that is likely to give satisfactory results.

Co-operative Work with the Bureau of Plant Industry.

In 1908 arrangements were made with Prof. W. M. Scott of the Bureau of Plant Industry, U. S. Department of Agriculture,

for some co-operative work between the New Hampshire Experiment Station and the Bureau of Plant Industry, one-half of the expense of the experiments to be paid by each party.

In preceding years Professor Scott had secured very satisfactory results in Arkansas and other sections of the south with various lime-sulfur solutions used as fungicides. In view of the possibility of injury from the various bordeauxs, it seemed especially desirable to test the comparative value of these lime-sulfur solutions and bordeaux under New England conditions. Arrangements were made to carry out such tests in the same orchards in which the experiments of 1907 were conducted. Six varieties of lime-sulfur solution and six different Bordeauxs were used.

Self-boiled Lime-Sulfur. In the preparation of the self-boiled lime-sulfur solutions, 15 pounds of fresh stone lime were placed in a 50-gallon barrel and 2 or 3 gallons of water poured over it. Ten pounds of sulfur were immediately added and another bucket of water. The heat from the slaking lime soon began to boil the mixture violently. Burning was prevented by stirring. If the mass became too thick to stir, more water was added, but the amount of water was kept at a minimum in order to secure the maximum of heat for cooking the mixture. 6 to 8 gallons of water were usually required. The barrel was covered with a piece of gunny sack to check the escape of the heat. The boiling continued from 20 to 30 minutes, according to the quality of the lime. When the boiling ceased the solution was diluted to 50 gallons for use.

In the presence of the heat a part of the sulfur combined with the lime, producing a dark brown liquid consisting largely of calcium sulfide, but much of the sulfur remained unchanged. The mixture was strained through a sieve of about 20 meshes to the inch, care being taken to work the sulfur and the finer lime particles through.

For the preparation of the 9-6-50 mixture given below, 6 2-3 gallons of water were added to each 10 gallons of the 15-10-50 solution.

Boiled Lime-Sulfur Solution. In the preparation of this mixture 2 pounds of lime and 1 pound of sulfur were boiled in a small quantity of water for 45 minutes and then diluted to 50 gallons. By this method of preparation the conversion of the sulfur was complete, producing a dark brown solution of calcium sulfid. A part of the lime was left unchanged and was worked through the sieve as in the above mixtures.

Unboiled Lime-Sulfur Solution. In the preparation of this mixture 9 pounds of lime were added to 25 gallons of water and 6 pounds of sulfur to another 25 gallons. Equal parts of these two solutions were mixed with thorough stirring. No heat was applied and the association of the lime and sulfur was merely a mechanical one.

Proprietary Lime-Sulfur Solutions. Two of the commercial lime-sulfur solutions were used, one prepared by the Thomsen Chemical Co., of Baltimore, Md., and the other by the Niagara Sprayer Co., of Middleport, N. Y. The mixtures put upon the market by these companies is such as would be obtained by boiling a lime-sulfur solution and decanting off the brown calcium sulfid solution for use. The Thomsen mixture was diluted in the ratio of 1 to 24 and the Niagara in the ratio of 1 to 49 before using.

Bordeauxs. Two strengths of home-made bordeaux and four proprietary mixtures were used. The latter were the Eagle, French, Standard and Grassellis preparations. These prepared paste Bordeauxs were diluted according to the directions on the packages.

The first spraying was made May 15th, before the flower buds had opened; the second May 27th, at the time the blossoms were falling; the third June 10th; the fourth June 18th, and the fifth July 30th. Paris Green was used at the rate of 6 oz. to 50 gal. in the 2nd and 4th sprayings. Notes were taken on the drops on August 14th and again Sept. 11th. The apples were gathered between Sept. 10th and Sept. 15th, and notes were taken on the picked fruit at the time of gathering. The following tables are based upon the data obtained from the picked fruit and the drops at the time of gathering. The badly scabbed apples were those so seriously damaged by scab as to be unmarketable.

Plot:	Fungicide.	Spraying.	Per cent. Badly scabbed.	Per cent. Slightly scabb'd.	Per cent Free from scab
	In the orchard of Arthur Ladd.				
1.	L. & S. 15-10-50 self-boiled..	1, 2, 3, 4, 5	2.9	45.	52.1
2.	L. & S. 9-6-50 self-boiled...	1, 2, 3, 4, 5	10.2	57.8	32.
3.	L. & S. 2-1-50 boiled.......	1, 2, 3, 4, 5	3.8	42.6	53.6
4.	L. & S. Thomsen...........	1, 2, 3, 4, 5	.9	9.4	89.7
5.	L. & S. Niagara...........	1, 2, 3, 4, 5	1.3	16.5	82.2
6.	Bordeaux 3-3-50...........	1, 2, 3, 4, 5	1.2	18.2	80.6
7.	Bordeaux Eagle............	1, 2, 3, 4, 5	1.7	24.5	73.8
8.	L. & S. 15-10-50 self-boiled..	1, 2, 4, 5	9.5	55.8	34.7
9.	L. & S. 9-6-50 self-boiled...	1, 2, 4, 5	7.1	46.4	46.5
10.	Bordeaux 3-3-50..........	1, 2, 4, 5	1.2	9.4	89.4
11.	Bordeaux 4-4-50...........	1, 2, 4, 5	2.7	5.6	91.7
12.	None		21.9	45.2	32.9

Plot:	Fungicide.	Spraying.	Per cent. Badly scabbed.	Per cent. Slightly scabb'd.	Per cent. Free from scab.
	In the orchard of Jonathan Smith.				
13.	L. & S. 9-6-50 unboiled...	1, 2, 4 and 5	23.3	42.9	43.8
14.	Bordeaux, Standard......	1, 2, 4 and 5	5.4	39.	55.6
15.	Bordeaux, Grasselli's......				
16.	Bordeaux, 3-3-50.........	1, 2, 4 and 5	3.6	20.6	75.8
17.	Bordeaux, French........	1, 2, 4 and 5	1.6	21.	77.4
18.	None		60.4	27.9	11.7

Plots 2, 8 and 14 were unfavorably situated and the large per cent. of scab may be partly due to this fact. The weather following the third spraying was dry and it is not surprising that the trees having this application gave but little better results than those without it.

The bordeauxs seem to have been the most efficient fungicides, with the proprietary lime-sulfur mixtures a close second. The calcium sulfid being far more soluble than the copper hydroxide, the lime sulfur solution washed off more readily than the Bordeaux. If the season had been a rainy one it is quite possible that there would have been a greater contrast in the efficiency of the two classes of fungicides, the change being in favor of the bordeauxs.

Judging from the prepared lime-sulfur solutions and from the lime-sulfur formulas used in preparing fungicides in the state of Oregon, it seems probable that the boiled lime-sulfur solution might have been used several times as strong.

The results obtained with self-boiled and with the unboiled lime-sulfur solutions do not indicate that either sulfur or lime is very efficient in controlling the scab. When viewed in connection with the results obtained with the proprietary and the boiled mixtures they emphasize the importance of the calcium sulfid and the necessity of heat in the preparation. The use of hot water in the preparation of the self-boiled mixtures, as has often been done by Professor Scott, would undoubtedly secure better results. It seems to the writer, however, that where it is possible to boil the mixture and make the chemical reaction between the lime and sulfur complete, better results will be obtained by doing this and using a smaller amount of sulfur than by using a larger amount of lime and sulfur and trying to regulate the extent of the chemical change by the amount of heat applied.

Too much emphasis should not be placed upon the results of one season but the lime-sulfur solutions are undoubtedly to be classed as valuable fungicides. They held the scab in check

almost as well as the bordeauxs, and produced no injury to foliage or fruit. In fact while there was occasionally an apple on the bordeaux plots whose appearance had been damaged by spray the apples on the lime-sulfur plots were smoother and apparently more waxy and more highly colored than on the check plots. It would seem that a very satisfactory treatment for an orchard would be found in making the first and possibly last sprayings with bordeaux and the second two with a lime-sulfur solution. The danger from bordeaux injury would thus be largely obviated. The McIntosh apple is less susceptible to bordeaux injury than the Baldwin, and far more susceptible to scab. The above suggestion is therefore, likely to be of more value in treating the latter than the former variety. The value of bordeaux and lime-sulfur mixtures in controlling fruit spot and leaf spot has already been discussed. (Pages 346, 369.)

Weed Destruction.

In the summer of 1907 wild mustard came up very thick in an oats field on the college farm. This was thoroughly sprayed with iron sulfate solution when the mustard plants were small. Two pounds of iron sulfate were used to each gallon of water and the solution applied at the rate of fifty gallons to the acre. The wild mustard was practically all killed with one application. The leaves of the oats were found to have a few black dead spots on them, but the injury was not serious. A similar experiment was made in 1908 with equally satisfactory results. The experiments show that iron sulfate is a valuable agency in the destruction of wild mustard if applied before it begins to make its stem growth. The best results are secured by an early application.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

E. DWIGHT SANDERSON.

The changes in the assistants in the department have been noted in the Director's report. These frequent changes have interfered with the work of the department, and the writer's duties as director have prevented as much personal entomological work as formerly.

During the past two years the offices and laboratories of the department have been moved entirely to Thompson Hall. Among the additions to equipment should be noted several large field cages for the study of insect life out of doors, several thermographs and thermometers, and a large constant temperature oven, built according to our plans, to maintain temperatures between 50 and 70 F., for use in our investigations of the relation of temperature to insect life.

INVESTIGATIONS.

It has been the policy of the department to concentrate effort upon but few investigations. The principal work has been upon the codling moth, which is reported herewith. Investigations of the Striped Cucumber Beetle, carried on in 1907, are also reported below. In July, 1908, a very unusual insect outbreak occurred throughout the hardwood forests on the hills of the state, which proved to be the work of the Antlered Maple Worm (*Heterocampa guttivitta* Walk) a native insect not heretofore known as injurious. In the writer's absence, his assistant, Mr. C. F. Jackson, was at once directed to fully investigate the outbreak and a week or two later the writer visited Ossipee and Tamworth and the White Mountain Region, to determine the extent of the injury. While Mr. W. M. Barrows visited towns lying between Laconia and Claremont, Mr. C. F. Jackson visited towns southwest of Concord and Mr. W. S. Abbott studied the conditions in Cheshire County. Mr. Jackson has prepared a report which summarizes our knowledge of the pest, which appears on page 514.

Investigations concerning the relation of temperature to insect life, as outlined in our last biennial report, have been carried on constantly, numerous experiments have been made and a large amount of data secured, but the work has not progressed sufficiently to warrant publication. Two papers upon special

phases of this work have, however, been published which are noted under Publications.

Correspondence and State Work.

The correspondence of the entomologist increases each year, and with the advent of the brown-tail and gipsy moths increased interest is being taken in combating all insect pests.

The entomologist has continued to act as nursery inspector for the State Board of Agriculture.

Besides publishing two bulletins and numerous newspaper articles upon the brown-tail and gipsy moths, the entomologist took an active part in calling the attention of the public to the danger from these pests and the need of state legislation for their control, through lectures and correspondence, and the law enacted by the last session of the General Court, was doubtless largely due to the public opinion thus aroused.

PUBLICATIONS.

The publications of the writer during the period of this report, have been as follows:

Publications of the New Hampshire Agricultural Experiment Station.

1907, January. Bulletin 128, The Brown-tail Moth and the Gypsy Moth in 1906. In colaboration with Dr. L. O. Howard. Pgs. 22, figs. 8. An account of the spread of these pests in 1906 and suggestions for their treatment.

April. Bulletin 131. Spraying the Apple Orchard. In colaboration with T. J. Headlee and Charles Brooks. Pgs. 48, figs. 37. The results of investigations of the life history and experiments in spraying for the codling moth in 1906, and the results of experiments against the apple scab and fruit spot, with directions for spraying.

1908, February. Bulletin 136. The Gypsy and Brown-tail Moths in New Hampshire. Pgs. 64, figs. 34. (Printed by order of the Governor and Council.) A revision of bulletins 121 and 122, brought up-to-date, and Chapter 147, Laws of 1907, N. H., concerning these pests.

July. Bulletin 139. Caterpillars Injuring Apple Foliage in Late Summer. Pgs. 24, figs. 13. A popular account of the fall web-worm, yellow-necked apple caterpillar, red-humped apple caterpillar, tussock moth, and hickory tiger moth, with directions for spraying for their control.

August. Circular 3. The Apple Leaf-aphis. Pgs. 6, figs. 4.

Circular 4. The Oyster-shell Scale, Scale. Pgs. 4, figs. 3.

Circular 5. The San Jose Scale. Pgs. 12, figs. 5. Pl. 1.

May. School Bulletin No. 1. Agricultural Education Through Rural Schools. Pgs. 20, figs. 7.

August. Press Circular, 11. An Outbreak of Forest Caterpillars.

August. Scientific Contributions No. 1. The Influence of Minimum Temperatures in Limiting the Northern Distribution of Insects. Pgs. 18. Maps 7. Reprinted from the Journal of Economic Entomology, Vol. 1, No. 4.

Other Publications.

1907, January. National Legislation to Control the Spread of Insect Pests. National Nurseryman. Pgs. 15, 16.

March. The War with The Insects. Farming. Pgs. 58, figs. 3.

April. A Spraying Calendar for the Home Garden. Garden Magazine. Pgs. 142-146, figs. 17.

November. What Research in Economic Entomology is Legitimate under the Adams Fund? Bulletin 67, Bureau of Entomology, U. S. Dept. Agr. Pgs. 77-84.

A Spray Nozzle for the Mechanical Mixture of Oil with Water or Other Liquids. L. c. pgs. 112-116, figs. 6, 7.

1908, February. The Relation of Temperature to the Hibernation of Insects. Journal of Economic Entomology. Vol. 1, Pgs. 56-65, figs. 1, 2.

April. Preliminary Report on the Life History of the Codling Moth and Spraying Experiments Against It. L. c. Pgs 129-140.

INSECTS RECEIVED FOR IDENTIFICATION.

Oct. 1, 1906 to Oct. 31, 1908.

COLEOPTERA.

Scientific Name.	Food.	Locality and Date.
Bruchus pisi Linn.	Beans.	Pittsfield, V, 5, '08.
Euphoria inda Linn.	Apple.	Dover, IX, 16, '07.
Galerucella luteola Mull.	Elm.	Claremont, VII, 16, '07.
Macrodactylus subspinosus Linn.	Beans, corn.	Tilton, V, 29, '08.
Meloe angusticollis Say.	Onions.	Pittsfield, VII, 19, '07.
" " "	Potatoes.	New Ipswich, IX, 17, '07.
Oberea bimaculata Oliv.	Raspberry.	Wolfboro, VII, 24, '08.
Pissodes strobi Peck.	Pine.	Milford, VII, 28, '08.
" " "	Pine.	Hillsboro, VIII, 1, '08.
" " "	Spruce.	Dublin, VII, 11, '08.
Prionus laticollis Dru.		Dover, VI, 11, '08.
Saperda candida Fab.	Apple.	Dover, VII, 30, '07.
Scolytus rugulosus Ratz.	Apple.	Newton Jct., VI, 10, '08.
Tenebriodes mauritanicus Linn.		Chester, XI, 7, '07.
		Monadnock, X, 12, '07.

HEMIPTERA.

Scientific Name.	Food.	Locality and Date.
Aphis gossypii Glov.	Canteloupe.	Concord, VII, 27, '08.
Aphis pomi Fitch.	Apple.	Boscawen, VI, 1, '08.
Aphrophora parallela Say.	Pine.	Laconia, VI, 22, '08; VI, 23, '08.
		Farmington, VI, 22, '08.
		West Canaan, VI, 1, '08.

HEMIPTERA.—*Continued.*

Scientific Name.	Food.	Locality ane Date.
Aspidiotus perniciosus Coms.	Apple.	Manchester, I, 7, '07.
		Chester, V, 1, '08.
		Rochester, X, 1, '08.
Ceresa bubalus Fab.	Apple.	Dover, V, 2, '07.
Chionaspis furfurus Fitch.	Apple.	Manchester, IV, 17, '07.
Gossiparia ulmi Fitch.	Elm.	No. Hampton, VII, 12, '08.
Clostoptera pini Fitch.	Pine.	Pittsfield, VI, 13, '08.
Lachnus strobi Fitch.	Pine.	Antrim, X, 14, '07.
		West Concord, XII, 2, '07.
		Hudson, IV, 20, '08.
Lepidosaphes ulmi Bouche.	Apple.	West Claremont, IV, 2, '07; Center Ossipee, IV, 8, '07; Hebron, IV, 11, '07; Bow, I, 23, '07; Walpole, I, 9, '08; Hampton, V, 13, '07; Concord, IV, 26, '08; Greenland Village, III, 22, '08; Gossville, XII, 26, '08; Portsmouth, IV, 29, '08; Candia, I, 24, '08; Laconia, VIII, 5, '08; Portsmouth, V, 19, '08.
	Lilac.	Manchester, V, 28, '08.
Lygus pratensis Linn.	Dahlia.	Epping, VIII, 27, '06.
Melanoxanthus salicis Linn.	Willow.	Manchester, X, 27, '07.
Nectarophora pisi Kalt.	Pea.	Grafton, VII, 27, '08.
Perillus claudus Say.		Ashland, VI, 22, '08.
Schizoneura americana Riley.	Elm.	Manchester, VII, 12, '07.
" " "		New Ipswich, VII, 8, '07.
" " "	Apple.	West Claremont, XII, 5, '06.
Schizoneara lanigcra Haus.		Mt. Vernon, XII, 9, '07.
" " "		Berlin Mills, VIII, 27, '06.
Tingis juglandis Fitch.		Orford, VII, 15, '08.

HYMENOPTERA.

Cimbex americana Lach.	Elm.	Dublin, VII, 31, '08.
Eriocampoides limacina Retz.	Cherry.	Weirs, IX, 6, '08.
Lophyrus lecontei Fitch.	Pine.	Holderness, VII, 27, '07.
Thalessa lunata Fab.		Laconia, VII, 24, '08.

LEPIDOPTERA.

Anisota rubicunda Fab.	Maple.	Harrisville, VIII, 30, '07; Peterboro, VII, 27, '08; New London, VII, 31, '08; Sullivan, VII, 31, '08; Laconia, VII, 28, '08; Andover, VII, 8, '08; Sanbornville, VII, 28, '08; Canaan, VIII, 19, '08; Ossipee, VII, 24, '08; Franklin, VIII, 24, '08; Laconia, VII, 24, '08.
Anisota rubicunda Fab.	Oak.	Centerville, VII, ?, '08; Conway Centre, VIII, 24, '08.
Anisota stigma Fab.	Maple.	Laconia, VII, 28, '08; Conway Centre, VIII, 8. '08.
" " "	Oak.	Center Harbor, VIII, ?, '08; Derry, VIII, 4, '08.
Ampelophaga myron Cram.	Grape.	Sanbornton, VIII, 5, '08.
" " "	Woodbine.	Sunapee. VII, 30, '08.
Apantesis virgo Cram.		East Hebron, V, 7, '06.
Automeris io Fab.		Conway, IX, 16, '07; South Lee, VI, 26, '07.
Basilona imperialis Dru.	Pine.	Atkinson, VII, 19, '07.
" " "		Hampton Falls, VI, 28, '07.

LEPIDOPTERA.—*Continued.*

Scientific Name.	Food.	Locality and Date.
Cacoecia cerasivorana Fitch.	Cherry.	Jackson, VII, 7, '07.
Calocalpe undulata Linn.	Cherry.	Harrisville, VIII, 30, '07.
Ceratomia amyntor Hub.		Canaan, IX, 19, '08.
Clisiocampa americana Fab.	Apple.	Canaan, III, 15, '07.
" " "		East Hebron, VII, 22, '07.
Datana integerrima G. & R.	Walnut	Exeter, VIII, '07.
Datana major G. & R.		E. Jaffrey, VII, 15, '07; North Weare, IX, 10, '08.
" " "	Apple.	New London, VIII, 22, '07.
" " "	Blueberry.	New London, VIII, 22, '07.
" " "	Walnut.	Dover, VIII, 20, '08.
Datana ministra Dru.		Canaan, IX, 8, '08; Antrim, VII, 18, '08.
" " "	Apple.	Bath, VII, 28, '07; Freedom, VII, 22, '07; Conway Centre, VIII, 29, '07; Enfield, IX, 11, '07; Sunapee, VII, 22, '07; Henniker, VIII, 11, '08.
Danais archippus Linn.		Dover, VIII, 29, '08; Hillsboro, IX, 3, '08.
Eacles imperialis Dru.		Salisbury, VIII, 19, '08.
Eugonia j-album Bd.		Wilton, III, 25, '07.
Euvanessa antiopa Linn.		Claremont, VII, 9, '08.
Halesidota caryae Harr.	Apple.	Harrisville, VIII, 30, '07; Dublin, VIII, 19, '07; New London, VIII, 9, '07; Holderness, X, 19, '07; Hancock, VII, 30, '08.
Halesidota caryae Harr.	Birch.	Tilton, VIII, 25, '07.
" " "	Butternut.	Holderness, X, 19, '07.
" " "	Elm.	Claremont, VIII, 23, '07; Wolfboro, IX, 17, '07.
" " "	Hickory.	Franklin, VIII, 10. '07.
" " "	Oak.	Center Harbor, VII, ?, '08.
" " "	Walnut.	Holderness, VII, 27, '07; Exeter, VII, 26, '07; Orford, IX, 16, '07.
" " "	Apple.	East Andover, VIII, ?, '07; Lakeview, IX, 13, '07; Boscawen, VIII, 28, '07; Holderness, X, 19, '07; Pittsfield, VIII, 17, '07; Contoocook, VIII, 8, '07; Sunapee, VIII, 22, '07; Hanover Centre, IX, 10, '07.
Halesidota caryae Harr.		Walpole, VIII, 8, '07; No. Sutton, VIII, 25, '07; Chesterfield, VIII, 19, '08; Suncook, IX, 16, '07; Franklin, VIII, 10, '07; Nashua, VIII, 2, '07.
Halesidota tesselata S. & A.		Bath, VIII, 27, '07.
Hemerocampa leucostigma S. & A.	Apple.	New Durham, III, 18, '07; Sutton, V, 5, '08; Rollinsford, VIII, 28, '07; Salmon Falls, II, 24, '08; Warner, VI, 24, '07.
Hemerocampa leucostigma S. & A.	Apple.	Epping, III, ?, '07; West Ringe, VI, 22, '07; Bath, VIII, 27, '07.
Hyphantria cunea Dru.		Mt. Sunapee, VIII, 12, '07; Chesterfield, VII, 7, '08.
" " "	Apple.	Woodsville, VII, 31. '07; Snowville, VIII, 19, '07; Winchester, VIII, 13, '07.
Hyphantria textor Harr.		Jackson, VII, ?, '08.
Icthyura inclusa Hubn.	Apple.	East Wakefield, IX, 24, '07.
Notolophus antiqua Linn.	Poplar.	Dover, II, 18, '07; Warner, VI, 21, '07; Hillsboro Bridge, V, 5, '07.

LEPIDOPTERA.—*Continued*

Scientific Name.	Food.	Locality and Date.
Oedemasia concinna S. & A.	Apple.	West Lebanon, IX, 17, '07; Stratham, VIII, 23, '07; Canaan, VIII, 19, '08; New London, VII, 31, '08; Center Harbor, VIII, 18, '08; E. Grafton, VIII, '08; West Rye, VII, 14, '07; East Andover, VIII, '07; No. Sutton, VII, 23, '07; Freedom, VII, 22, '07; Marlow, VIII, 26, '07; Contoocook, X, 1, '07; Warner, VIII, 12, '07; Laconia, X, 19, '07; Enfield, IX, 11, '07; Boscawen, VIII, 28, '07; Hooksett, IX, 19, '07; Henniker, VIII, 20, '07; Peterboro, VIII, '07; New London, IX, 11, '07; Sunapee, VIII, 22, '07; Antrim, X, 7, '07; Walpole, IX, 10, '07; Franklin, VII, 15, '07.
Papilio turnus Linn.	Cherry.	New London, IX, 11, '07.
Phobetron pithecium S. & A.	Plum.	Westville, IX, '08.
" " "		Nashua, IX, 10, '07; New Durham, IX, 1, '08.
Samia cecropia Linn.		Enfield, X, 10, '08; Chester, VIII, 27, '08; Sunapee, V, 8, '08; No. Haverhill, IX, 3, '07; Suncook, XI, 11, '07; Highlands, XI, 29, '07; Mason, III, 17, '08; Center Sandwich, II, 18, '08; Hopkinton, I, 22, '08; West Campton, III, 3, '08.
Samia cecropia Linn.		Rollinsford, VII, 17, '08; Dover, IV, 28, '07; Salmon Falls, II, 24, '08; Greenville, II, '19, '07; Freemont, VIII, 15, '07; Antrim, IX, 3, '07; Ossipee Valley, XII, 4, '06; Hill, XI, 27, '06; New Boston, III, 24, '07; Hinsdale, III, 14, '07; Stratham, III, 25, '07; Hampton, IV, 4, '07; Wilton, III, 20, '07; Kingston, III, 19, '07; Bedford, XII, 20, '06; Enfield, XII, 10, '06; Candia, III, 16, '07; Alton Bay, III, 1, '07.
	Apple.	Newton, V, 20, '07.
Samia promythia Dru.		New Durham, III, 27, '07; Chester, I, 27, '08; Highlands, XI, 29, '07; Rollinsford, IV, 2, '08; Enfield, XII, 5, '06.
Sphinx drupiferarum S. & A.	Apple.	No. Haverhill, VIII, 30, '07.
" " "		Hollis, VI, 22, '07.
Thyreus abbottii Swan.	Woodbine.	Wolfeboro, VIII, 10, '07.
" " "		W. Henniker, VIII, 5, '07; Concord, VIII, 5, '07; Whitefield, VII, 29, '08.
Thyridopteryx ephemeraeformis Harr.	Arbor vitae.	Hillsboro Bridge, X, 4, '06.
Tortrix fumiferana Cle.	Spruce.	Laconia, VIII, 9, '07.
Aetia luna Linn.		Enfield, VI, 15, '08; East Unity, VII, 5, '07.

NEUROPTERA.

Corydalis cornuta Linn.		Contoocook, VII, 26, '08.

ACARINA.

Phytoptus pyri Sch.	Pear.	Weirs, VIII, 5, '07; Concord, VIII, 15, '07.
Dermanyssus gallinae Redi.	Chickens.	Bristol, VII, 5, '07.

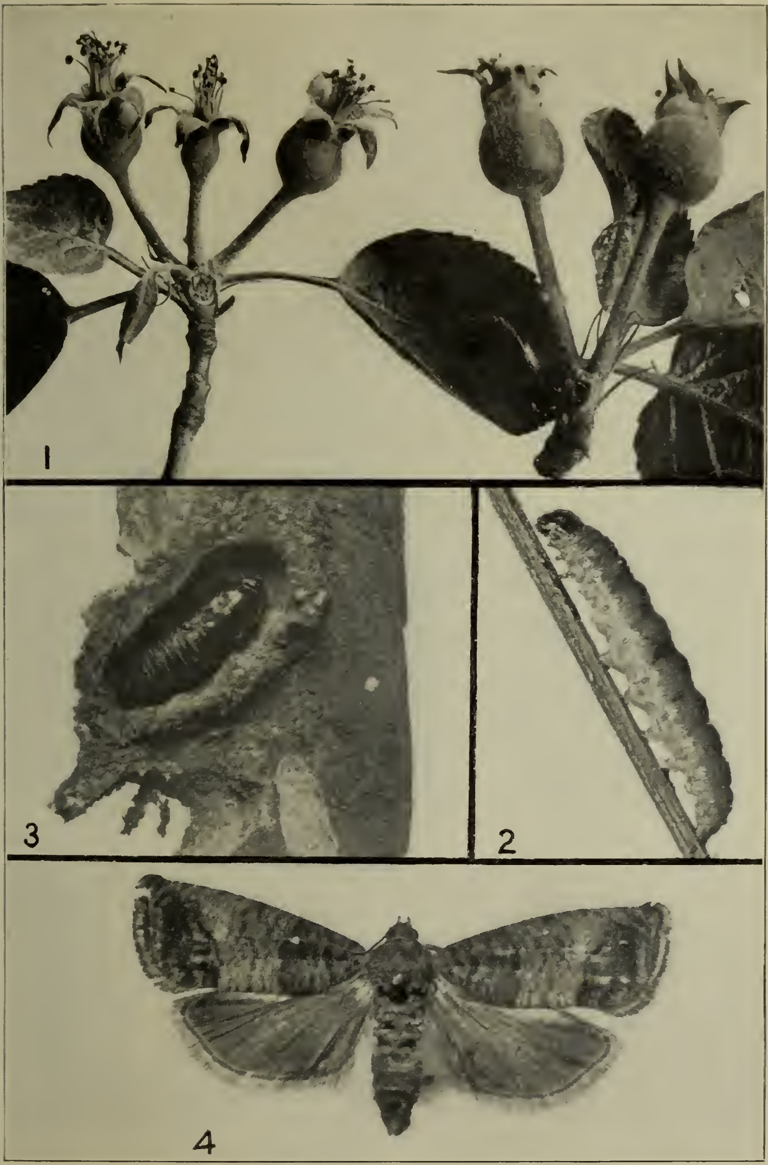
CODLING MOTH INVESTIGATIONS.

A popular account of the work upon the codling moth of 1905 and 1906 was published in Bulletin 131. Since then more elaborate experiments in control have been made and the studies of the life history have been repeated. In the present report the data accumulated during the years 1905, 1906, 1907 and 1908 will be presented. Although there are still many phases of the life history and habits of the codling moth not fully known, and although further studies of the effect of various kinds of sprays would be of interest, it is felt that the studies of the past four years have brought out the essential points as regards habits and means of control of this most important pest of the apple, and this report will probably conclude our work upon it for the present. In carrying out the details of the work the writer has been assisted by Dr. T. J. Headlee, C. S. Spooner, and C. F. Jackson, who have been immediately responsible for the observations and records, and to whom much credit is due for careful work.

FIG. 18. The codling moth.

LIFE HISTORY.

Hibernation. The larvae hibernate over winter in cocoons which are located mostly in the bark of the trunk and limbs of the trees. Usually the larva mines into the corky wood of a crevice in the bark, and there spins its cocoon. Rarely are cocoons found under loose flakes of bark, although larvae will readily spin up in burlap bands, under an old bag, in the crotch, etc. Occasionally cocoons may be formed under clods of earth, and, probably often under boards, rubbish, fences, etc., but we have observed few in such situations in the orchards under observation. In May, 1907, a careful study of seven trees in a badly infested old orchard was made to determine the position of the cocoons on the trees, as well as the condition of the larvae. Out of 385 cocoons found on the seven trees, 70 per cent. were on the trunk and the remainder on the main branches.



THE CODLING MOTH AND ITS CONTROL.

Fig. 1.—Young apples, showing, on left, calyx lobes open, and in right condition for first spraying; on right, calyx lobes closed, and almost, if not quite, too late for spraying. Fig. 2.—The codling moth larva, or apple worm. Fig. 3.—Codling moth pupa, in its cocoon, under scale of bark from trunk of apple tree. Fig. 4.—Codling moth or parent of apple worm. Figures 2, 3, and 4 enlarged about three times. (After Quaintance, U. S. Dept. Agr.)

Of those on the trunk 97 were within one foot of the crotch, 112 were within one foot of the ground, and 60 were between on the middle portion of the trunk. In counts of larvae collected from

FIG. 19. Remains of the white cocoons of the codling moth revealed by scraping off the bark covering them.

bands on nine unsprayed trees the same season it was found that out of 640 larvae 58 per cent. were from the lower bands, where one band was placed just below the crotch and another

just above the ground. We have frequently observed more larvae at the base than higher on the tree. On these seven trees were 51 limbs, but on only 26, or one-half of the limbs, were any larvae found. On each limb the distance of the larva farthest from the base of the limb was noted, and this varied from one to ten feet, with an average of 3 feet 8 inches. It is therefore safe to assert that the larvae are usually found only on the larger limbs within about three feet of the crotch.

At the same time a record was made of the condition of the larva in each cocoon and the cause of mortality, as far as it could be determined. The following table gives the record ot the 7 trees:

TABLE 1. *Giving mortality of codling moth larvae during hibernation.*

Tree.	Total larvae on trunks.	Alive.	Killed by		
			Birds.	Fungus.	Cold.
1.	36	4	28	0	4
2.	46	2	42	2	0
3.	41	3	33	2	3
4.	25	1	22	1	1
5.	74	2	67	5	0
6.	35	2	31	1	1
7.	12	0	11	1	0
Total per tree,	38.5	14	234	12	9
		5%	87%	4%	3%

In another badly infested orchard 1096 cocoons were examined during May 1907. In these 19 per cent. were alive, 66 per cent. had been killed by birds, 6 per cent. had been killed by fungus and 9 per cent. by cold. Very often when seeking larvae in the spring it is difficult to find living specimens as practically every cocoon has been emptied by the woodpeckers. It is quite evident, therefore, that the birds are the most important natural enemies of the codling moth in New England, and should be given every protection and attracted to the orchard in every way possible.

Pupation. In 1906 the average date of pupation for 43 larvae was May 25, and the average length of the pupal stage 20 days, the majority of the adults appearing about June 14. In 1907 the average date of pupation for 103 larvae was June 16, the average length of the pupal stage being 16 days and the majority of the adults appearing about July 2. The larvae observed in both

the above years, were collected from trees in the spring and kept in an unheated room with windows open. In 1908 83 larvae were secured in the same way and kept under similar conditions. The time of pupation and emergence is shown in Table 2. It will be noted that the first larva pupated May 20, the last June 9, and the average about June 1. The average length of the pupal stage was 19 days, the majority of the moths emerging about June 20.

TABLE 2. *Pupation and emergence of the Codling Moth; larvae collected May 13, 1908.*

Pupated		Time Pupa			Moths Emerged.	
Date.	Number.	Average.	Minimum.	Maximum.	Date.	Number.
May 20	1	17			June 6	1
" 21	2	21			" 11	1
" 23	3	21	21	22	" 13	5
" 25	5	20 1-2	19	21	" 14	3
" 26	7	20			" 15	12
" 27	4	20	19	21	" 16	5
" 28	11	19 1-3	16	22	" 17	5
" 29	8	20	17	21	" 18	2
June 1	28	19	16	20	" 19	17
" 3	1	16			" 20	13
" 6	2	15			" 21	9
" 7	7	15	14	16	" 22	4
" 8	2	16 1-2	16	17	" 23	2
" 9	2	16			" 24	1
					" 25	3

137 larvae had been collected in August and September, 1907, from the same trees as the above, the larvae collected from these trees in May, 1908, having all spun up after Sept. 21, 1907, when the last were collected. Those collected in the fall were placed in gelatin capsules and kept in a dry, wooden box in a pine grove all winter, and were brought into the same quarters as those collected in May, at the same time. As will be seen in Table 3 they emerged a week or ten days later than those collected in May, and the pupal stage lasted but 16 days against 19 days, corresponding exactly with the time of the pupal stage in 1907. Furthermore those collected Aug. 19, 1907, pupated slightly before those collected Aug. 29, and those collected in August pupated five or six days earlier than those collected Sept. 21. The same is more markedly true of the time of emergence of the moths, the earlier collections emerging earlier, there being about a week difference in the time of emergence between those collected Aug. 19 and Sept. 21.

TABLE 3. *Pupation and emergence of Codling Moth larvae collected during August and September, 1907.*

Date	Pupated: Total Number	Coll. 8-19	Coll. 8-29	Coll. 9-21	Time Pupa: Average	Maximum	Minimum
May 18	3		3		23		
" 19	2			1	22		
" 20	1			1	17		
" 21	1	1			21		
" 23	3		3		21		
" 25	4	3	1		21		
" 26	4	1	3		20		
" 27	1		1		23		
" 28	10	3	6	1	20	19	21
" 29	3	1	1	1	21½	21	22
June 1	19	5	13	1	19	18	20
		—½					
" 3	1	1			18		
" 4	6		5	1	18	17	19
" 6	4	1	2	1	16½	15	17
" 7	9	2	7		16½	15	18
" 8	4		2	2	15½	15	16
			—½				
" 9	5		2	3	16	14	17
" 10	10	2	7	1	16.8	16	17
				—½			
" 11	4		4		17	16	18
" 12	7		5	2	17	16	18
		—¾	—¾				
" 14	15	1	13	1	16½	15	17
" 15	1		1		16		
" 16	8	2	3	3	15	11	17
" 17	2	1		1	16	15	17
				—¾			
" 19	1		1		15		
" 20	1			1	16		
" 21	1	1			15		
" 22	1			1	15		
" 23	6	2	1	3	13	10	14

Moths Emerged.

Date.	Total Number.	Coll. 8-19.	Coll. 8-29	Coll. 9-21.
June 11	1	1		
" 13	4	2	2	
" 14	2	1	1	
" 15	8		8	
" 16	3	1	1	1
" 17	4	1	3	
" 18	1		1	
" 19	9	3	5	1
" 20	10	3	6	1
		—½		
" 21	8	2	6	
" 22	5	1	3	1
" 23	12	1	8	3
			—½	
" 24	6		4	2
" 25	4	2	1	1
" 26	2		1	1
		—¾		—½
" 27	8	1	5	2
" 28	6		5	1
" 29	4		4	
			—¾	
" 30	1			1
July 1	9	1	8	—¾
" 2	8	1	6	1
" 3	5	1	3	1
" 4	4	3		1
" 6	2		2	
" 7	3			3

TABLE 4. *Duration of the Pupal Stage of the Codling Moth.*

A. Raised in insectary room; average temperature 70° F.

Date pupated 1908.	Collected May 13 1 No.	2 Days.	3 Temp.	Collected Aug. 19 No.	Days.	Temp.	Collected Aug. 29 No.	Days.	Temp.	Collected Sept 21. No.	Days.	Temp.
May 21				1	22	773						
" 23							2	21	785			
							1	22	828			
" 25	1	21	798	1	19	713	1	21	798			
				1	20	755						
				1	21	798						
" 26	3	20	760	1	20	760	3	20	760			
" 27	2	20	752				1	19	714			
	1	21	787				1	23	863			
" 28	1	16	594				1	16	594			
	2	19	717	1	19	717	1	19	717	1	19	717
	2	20	752	1	20	752	3	20	752			
	2	21	787				1	21	787			
	2	22	828	1	22	828						
" 29	1	18	683				1	17	645			
	6	21	794	1	21	794	1	21	794	1	22	834
June 1	1	17	609	1	18	685	3	18	685	1	18	685
	8	18	685									
	13	19	725	3	19	725	6	19	725			
	6	20	763	1	20	763	4	20	763			
" 3	1	16	623	1	19	739						
" 4							2	17	667			
							2	18	705			
							1	19	744	1	19	744
" 6	1	14	566									
	2	15	603	1	15	603	2	17	680	1	17	680
" 7	4	15	604				1	15	604	1	15	604
	2	16	643	1	16	643	3	16	643			
				1	18	713	3	17	678			
" 8	1	16	624				1	15	601	1	15	601
	1	17	661				1	16	626	1	16	626
" 9	2	16	626				1	14	554	1	15	589
							1	16	624	1	16	624
										1	17	660
" 10	1	15	580									
	3	16	616	1	16	616	2	16	616			
	1	17	648	1	17	648	4	17	648	1	17	648
							2	18	680			
" 11	1	17	639				2	17	639			
	1	18	671				1	18	674			
" 12	1	17	634				1	16	599			
							2	17	634	1	17	634
							2	18	672	1	18	672
" 14				1	17	625	1	15	554			
							7	16	590			
							5	17	625	1	17	625
" 15							1	16	582			
										1	11	404
" 16	1	17	622	1	17	622	1	15	544	1	15	544
							3	16	584	1	16	584
" 17				1	15	549				1	17	626
" 19				1	15	550						
" 20				1	16	599						
" 21				1	15	561						
" 23				1	13	484	1	11	395	1	15	571
	Weighed Average of 74—18.5.			Wt. Average 27—18			Wt. Average 83—17.6.			Wt. Average 20—16.6.		

B. Raised in Laboratory; average temperature 71° F.

Date pupated 1908.	Collected May 13 1 No.	2 Days.	3 Temp.	Date pupated 1908.	Collected May 13 1 No.	2 Days.	3 Temp.
May 11	1	30	1145	May 27	3	14	545
" 15	1	26	1011		2	15	588
" 17	1	24	922		1	17	676
" 18	3	20	787	May 28	1	11	412
" 23	1	16	616		3	13	505
	1	18	709		5	14	548
" 25	1	12	459		1	15	592
	2	13	497	" 29	1	11	420
	1	15	585		1	12	467
	1	16	632		3	13	510
" 26	2	12	456		1	14	554
	1	14	545		2	15	598
	3	15	591	June 1	1	14	576
" 27	1	13	498		Weighted average 45—15.1		
					Total weighted ave. 249—16. Days		

Note:—1. Number pupated.
2. Days pupated.
3. Total temperature above 32° F.

Relation of Temperature to Pupal Stage. Table 4 shows the number of larvae which pupated each day, the number of days in the pupal stage and the total accumulated temperature above 32 degrees F. during that time. The lots are divided according to the time collected, for convenience in comparison. One lot collected in May was placed in the zoological laboratory, which was thought to be a warmer room. The thermograph records show that it averaged 71 degrees against 70 degrees in the basement room in which the rest were kept, but that the temperature was somewhat more uniform. Why the pupae in the laboratory should emerge in an average of 15.1 days while those in the basement should require 17.7 days, with a corresponding amount of total temperature, is a mystery. It will also be observed that the amount of temperature required varies with the number of days pupa, as the average temperature of the rooms was practically constant during the period, but that the first to pupate required several more days than those pupating last, there being a regular decrease in the number of days in the pupal stage and the temperature increment from the first to the last pupation. Also there is a difference of five or six days in the length of the pupal stage of individuals pupating on the same day. Were not our records exactly paralleled by those of Simpson (Bull. 41, Div. Ent., Tables IV. and V.), we would have doubted their accuracy, but there seems no good reason for such suspicion. It is to be regretted that the records were not made out of doors under natural conditions, and further

studies of the relation of temperature to the transformations of the codling moth will be made under natural conditions, but as Simpson's cages were placed under exactly the same conditions as prevailed in the orchard, there is reason to believe that the transformations of this insect are quite variable, and that other factors than temperature are of great importance. It will be observed, however, that although there seems to be no definite

ERRATA.

Page 401. Table 4. Line two of heading, read 66.2° F. for 70° F.

Page 402. Line one, heading of table, read 72.8° for 71° F. Line five, text, commencing "One lot" etc., omit the balance of page and balance of sentence on page 403.

Further study of the temperature records made after the text went to press showed the temperature of the laboratory to be 6.6° higher than the insectory room, which may account for the shorter pupal period. A full discussion of this data will be published later in some studies of the relation of temperature to insect transformations.

of about one day for every seven days later in the season. Fig. 20 shows the normal curve for the mean monthly temperatures at Durham, N. H. From it may readily be determined the heat increment above 32 degrees for a given number of days at any point. It will be found that a pupal period, commencing on May 25 of 18 days, on June 1 of 17 days, on June 7 of 16 days, and on June 15 of 15 days, will require a total normal temper-

B. Raised in Laboratory; average temperature 71° F.

Date pupated 1908.	Collected May 13 1 No.	2 Days.	3 Temp.	Date pupated 1908.	Collected May 13 1 No.	2 Days.	3 Temp.
May 11	1	30	1145	May 27	3	14	545
" 15	1	26	1011		2	15	588
" 17	1	24	922		1	17	676

pupal stage and the temperature increment from the first to the last pupation. Also there is a difference of five or six days in the length of the pupal stage of individuals pupating on the same day. Were not our records exactly paralleled by those of Simpson (Bull. 41, Div. Ent., Tables IV. and V.), we would have doubted their accuracy, but there seems no good reason for such suspicion. It is to be regretted that the records were not made out of doors under natural conditions, and further

studies of the relation of temperature to the transformations of the codling moth will be made under natural conditions, but as Simpson's cages were placed under exactly the same conditions as prevailed in the orchard, there is reason to believe that the transformations of this insect are quite variable, and that other factors than temperature are of great importance. It will be observed, however, that although there seems to be no definite heat increment which will cause the emergence of the codling

FIG. 20. Curve showing average mean temperature at Durham, N. H.

moth, yet, if the average of all the records are taken, there is an approximately regular decrease in the number of pupal days of about one day for every seven days later in the season. Fig. 20 shows the normal curve for the mean monthly temperatures at Durham, N. H. From it may readily be determined the heat increment above 32 degrees for a given number of days at any point. It will be found that a pupal period, commencing on May 25 of 18 days, on June 1 of 17 days, on June 7 of 16 days, and on June 15 of 15 days, will require a total normal temper-

ature of 470 to 480 degrees, which is practically a thermal constant. The number of days required for the pupa from these different dates corresponds fairly well with the average of all those recorded in the above tables. It would seem then that the emergence in an abnormally high and uniform temperature requires about the same length of time as it would out of doors, and that other factors than temperature must control the time of pupation and emergence. Other studies of the relation of the codling moth to temperature conducted in greenhouses during the winter, and not yet ready for publication, indicate the same fact. The average length of the pupal stage of 249 individuals is found to be 16 days. Simpson gives 22 days for the cocoon stage and states that the larva exists in the cocoon six days before pupating. All of our observations were made on individuals in glass vials, which enabled us to give the exact date of pupation. Thus the average time agrees exactly, as an addition of six days to our average of 16 gives 22 as made by Simpson. It should be noted that our records are of the hibernating brood of larvae, whereas those of Simpson and others seem all to be made on the summer brood pupating in early August.

TABLE 5. *Relation of time of emergence of Codling Moth to dropping of apple blossoms.*

Year.	Petals fell.	First moth.	Majority moths.	Last moth.	Days first eggs hatch after petals fell.	Days majority hatch after petals fell.
1906.	May 29	June 9	June 14	June 26	21	26 (*10)
1907.	June 12	" 13	July 2	July 8	11	30 (*19)
1908.	May 26	" 6	June 19	June 25	21	30 (* 7)

Time of Emergence of Moths. The fact that the larvae which mature and cocoon first transform and emerge first the next spring, is of significance in connection with the amount of damage done by the second brood, and its prevention. The moths emerging first give rise to the few larvae which mature and form the partial second brood, which does considerable damage. If the drops were destroyed in August of the previous year, there would be fewer early moths and less of the second brood the next year.

Table 5 shows the relation of the time of appearance of the moths to the time of the apple blossoms dropping. It is usual to give the first spraying for the codling moth just after the petals drop. Moths do not usually oviposit until four to six days after emerging, and continue to oviposit for from ten to

*Days in egg stage.

thirty days, but if we assume that all the eggs are laid as soon as the moths emerge, and that they hatch in 10 days, we find that the first eggs would not hatch until about three weeks, and the majority of eggs not until about four weeks after the blossoms fall. This is of importance as determining the time of the second spraying to catch the newly hatched larvae on the freshly-poisoned foliage, and shows that it may usually be given about three to four weeks after the petals drop.

Length of Life of Moth. Simpson has given the average life of 47 moths as 4 days, but as egg records were secured from but two of these moths, and as they received no food or water, it is evident that they were under extremely unnatural conditions. Slingerland states that he has observed a moth for 17 days. In 1906 we erected three large cages covered with cheese cloth (Fig. 21) covering trees 10 to 12 feet high. These were placed over the trees before moths had commenced to emerge, and the leaves were carefully examined to see that no eggs had been laid before the moths were introduced. A pair of moths was then introduced into each of the three cages. It was im-

FIG. 21.—One of the large cages used in the study of the apple worm.

possible to follow the individual moth in so large a cage, but frequent examination of the foliage showed the number of eggs laid and the approximate date at which they were laid, thus giving a very correct idea of the length of life of the moth. In one case a moth was actually observed in the cage about three

weeks after its introduction. Our records of moths which failed to oviposit or deposited merely a few eggs would confirm Simpson's records, but the six moths which have laid a considerable number of eggs and lived under fairly normal conditions, lived from 5 to 28 days, averaging 13 days.

Oviposition. If the evenings be warm when female moths emerge, they will oviposit in three to five days after emergence. But if the evenings be cool, egg laying will sometimes be deferred for several days. From June 9 to 15, 1906, we were able to secure eggs, but after that the evenings were cool until the latter part of the month, and no eggs were secured until June 28. In 1907 no eggs were secured until June 22 or about the time of the maximum emergence of moths, though moths had been emerging since June 10, and had been paired in cages as fast as emerging. Owing to the extreme difficulty with which oviposition is secured with moths confined, it is difficult to determine the probable average period of oviposition. The period of oviposition for four moths, of which we have accurate records, not counting a large number which laid less than 10 eggs, varies from two to twelve days, averaging about eight days, but as indicated above in discussing the length of life, this will depend very largely upon the temperature. This is further shown by field records. Each year records were made of eggs on young bearing trees to determine their location, as described below, and incidentally the condition of the eggs was noted, so that the date of oviposition can be quite closely approximated. In 1906, though the last moths emerged June 26, but few eggs could be found until after July 5. In 1907, the majority of moths emerged July 2, and the last July 8, in confinement. Most all eggs were found hatched in the field on July 12, showing that they were laid about July 1 to 5, but 32 out of 246 were unhatched on July 14, and three were unhatched July 20. In 1908 eggs were laid in confinement from June 22 to July 8, but on three trees examined every two days, they were laid from June 18 to July 14, the maximum being about July 1. From the three years' observations it seems safe to assert that in this climate the eggs are usually laid about July 1, though the exact time will depend upon the fluctuations of the season. It is also evident from our records that eggs are being laid by different individuals for about one month.

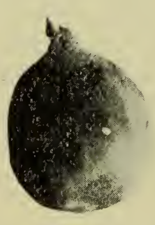


FIG. 22. Codling moth egg on apple, about natural size.

Out of, probably, over 100 female moths placed with males during our three years' observations but 15 have oviposited at all, and of these but five have laid over 15 eggs. These five laid 29, 52, 58, 89, and 136 respectively, averaging 73. The females placed in the large outdoor cages in 1906 gave 29, 58 and 89, averaging 59. The individual which laid 136 in 1908, was fed on moistened sugar in a small cage in an open room, as were all others that year. Eight other females laid forty eggs, varying from one to thirteen, averaging 5, in 1908. In 1907 we were wholly unable to secure any oviposition. Records by previous observers range from 2 to 85 eggs, the general opinion seeming to be that about 50 may be laid. It would seem safe to assert from the above, that at least 60 to 75 eggs are usually laid and probably often 100 or more. Many of the eggs seem to be sterile or fail to hatch as in 176 observed in 1908, only 66 hatched.

Position of Eggs. Records have been kept of the position of the eggs on three trees for three years. These records were made by examining every leaf, stem, and apple on each of the trees every few days during the period of oviposition, and noting the distance of the egg from the tip of the branch, and from the nearest apple and whether it was on the upper or under surface of the leaf, fruit, or bark. 796 eggs have been recorded in the three years and their position is shown in Table 6. The records of the three trees in 1906 are of particular interest, as these trees were enclosed and the eggs on each were deposited by one moth, while in 1907 and 1908 the records were taken from trees in the open. All of the records, except as indicated, are from summer or fall varieties of apples, from trees ten to twelve feet high.

TABLE 6. *Position of eggs of the Codling Moth.*

Year.	Tree.	Number eggs.	Average distance to apple.	On upper leaf.	On lower leaf.	On fruit.
1906.	1	58	28 in.	4	54	
	2	29	4.71	23	2	4 on bark.
	3	69	16.48	22	36	5 on fruit. 1 on bark.
1907.	1	246	7	29	227	
	2	31	0	9	22	
	3	209	9.4	119	86	
	4	33	2.6	14	17	2 on fruit.
1908.	1, 2, 3	46	12	41	5	
1906 in indoor cages.		77		44	33	1
Total.		796	Weighted 9 inches.	305	482	7 on fruit. 5 on bark

It is evident that the eggs are not usually laid on leaves immediately next to the apples. Large numbers are laid on foliage of non-bearing limbs. On the tree bearing 58 eggs in 1906, 22 were on branches having no apples, and in 1907 we found 31 eggs on a tree with no fruit whatever. It is, of course, perfectly evident, as has been shown by Card, Ball, and others, that practically all the eggs of this first brood are laid on the foliage. The eggs seem to be laid indifferently on the upper or under surface of the leaves when the under surface is smooth, but avoiding the under surface when fuzzy. The distance to the nearest apple is a matter of practical importance in relation to the habits of the young larva and spraying for its destruction, and is shown to be about 9 inches. In 1907 and 1908 an effort was made to determine whether the distance from an apple to the nearest egg would influence the infestation of the apple. To determine this the eggs on three trees, as recorded in Table 5, were found and each one numbered with a string tag. The apple nearest to each egg was then determined and numbered and recorded. On the stem of the apple was placed a tag bearing its number and the distance to the nearest egg, with the egg number. As the apples dropped the tags went with them and were collected every few days, and the record of the picked fruit was also made. A careful study of the records for three seasons fails to show that the distance of the nearest egg bears any relation to the worminess of the apple. The average distance for the nearest egg from wormy and non-wormy apples is practically the same. Wormy apples are found where the nearest egg was a foot or more distant, and others were not wormy where there were eggs within two or three inches. These observations would indicate that there must be a very large mortality of young larvae between the eggs and the apples.

Duration of Egg Stage. The rearing work was carried on in a basement room with open windows in 1908, and a comparison of thermograph records kept there, with the official records taken by the station, shows the mean temperature to be practically the same but with slightly less diurnal variations indoors.

One of the large frames used to cover one side of a tree by opening one side for the admission of a large limb.

Limb cage used in life history studies of the codling moth.

FIG. 1. Egg of codling moth on leaf—greatly enlarged and natural size.

FIG. 2. Young codling moth larva just hatched with egg shell—enlarged.

FIG. 3.—Empty pupa case of codling moth, showing tube spun out from cocoon by larva (cotton to which cocoon was attached forming background.)

TABLE 7. *Duration of egg stage of the Codling Moth.*

Date Laid.	Number Laid.	Date Hatched.	Number Hatched.	Incubation Period Days.	Average Temp. °F	Total Over 32°F	Total Over 43°F
1906							
June 10	51	June 10	50	10	*64	323	213
June 27	20	July 4	16	7	*74	293	216
1908							
June 22	†3	July 2	2	10	67.5	355	245
" 23	†9	" 1	9	8	67	281	193
" 24	†2	" 1	?	7	67	246	169
" 25	†40	" 2	20	7	67	246	169
" 27	†7	" 4	1	7	69	264	·87
" 28	†18	" 4	10	6	69	229	163
July 2	†11	" 7	7	5	73	206	151
June 24	1	" 2	1	8	67	281	193
" 26	1	" 2	1	6	67	210	144
" 26	10	" 3	2	7	68	250	173
Total and Weighted Averages			118	8.2	67	286	196

With practically the same average mean temperatures Simpson found that it required an average of 11 days with 302 degrees F. above 43 degrees F., to incubate the eggs. Gillette's records agree fairly well with our observations. Two reasons for this discrepancy may be suggested. Simpson's work was done out of doors, presumably in an orchard from his account, whereas the weather records quoted are those of the Weather Bureau at Boise, Idaho, which is doubtless located on top of a building in the city. Temperatures would probably be considerably lower on the leaves during mid-day than in the city. Again, the temperatures in the room used by us in 1908 did not have so great diurnal fluctuations, although the mean was practically the same as out of doors. Our knowledge of the influence of temperature upon the transformations of insects is so limited that we can not state whether a more uniform temperature would conduce to more rapid incubation, but it seems entirely probable. The great difficulty with which codling moth eggs are secured under anything like normal conditions from fairly normal females, renders it almost impossible to secure really accurate data upon this point without more effort than the subject warrants. At least a thousand eggs would need to be recorded, before any very reliable conclusions as regards the relation of temperature could be made, and until we know more

---

*No record of temperature was kept in this room which was unheated, with windows open. A comparison of thermograph records kept in the same room under same conditions in 1907 shows that it averaged about 5 degrees F. warmer than the official weather records of the station. By adding 5 degrees to the temperatures of the dates involved the average temperature given is secured.

†All laid by one female.

of the relation of temperature to species which breed more readily in confinement, it seems hardly worth while to attempt further study of this point. It is safe to assert that the eggs usually hatch in from seven to ten days. The only other conclusion which seems fairly evident from Simpson's observations and those above, is that the eggs are deposited at different stages of embryonic development.

Feeding Habits of the Young Larvae. Upon hatching from the eggs the young larva first feeds upon the foliage, mining

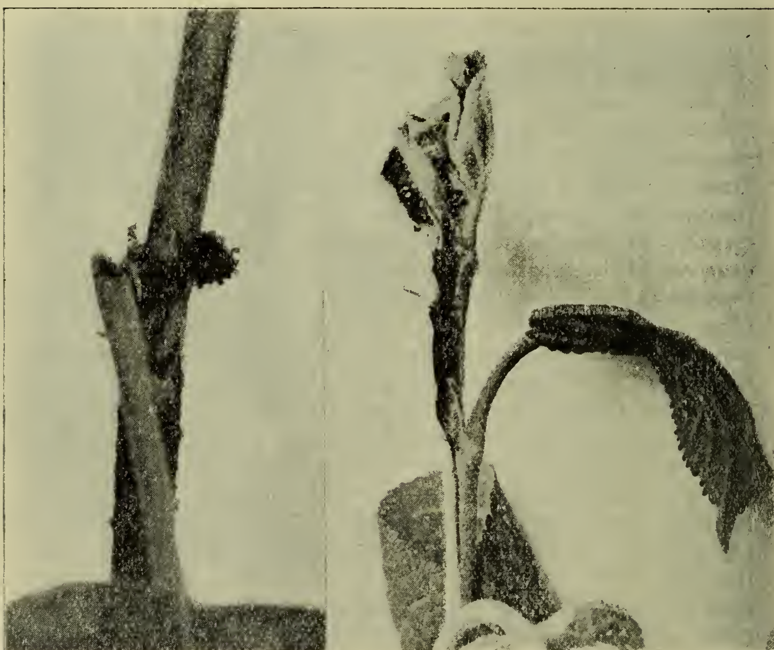


FIG. 23. Waterspouts of apple tunelled by codling moth larvae.

into the leaf at the angles of the mid-rib and branch veins, and gnawing the softer portions of the surface, more often on the under surface. This has been repeatedly observed, both in the laboratory and in the field. Whether larvae normally mature on foliage alone has not been determined from field observations, but we have shown that they will mature on foliage alone in the laboratory or in outside breeding cages, and it seems highly probable that when no fruit is available that larvae might mature on

foliage alone. This view is supported by the fact that considerable numbers of eggs are found on limbs bearing no apples on trees with no fruit. July 4, 1906, a larva just hatched was placed on a water sprout by Dr. Headlee. It tunnelled the tip of the sprout (see Fig. 23) and finally constructed a cocoon in the cork of the rearing tube on July 21, and pupated July 26. On June 19, 1908, Mr. Jackson isolated six male and six female moths in a large limb cage, which were provided with sweetened water and left undisturbed. On July 9 the first examination was made and six half grown larvae were found feeding in the tips of water sprouts, on the leaves, and in the bark. On July 13 three practically full grown larvae were found, each buried in the end of a twig which was fast dying. One larva was removed to a fresh twig in a glass cylinder indoors. On July 16 these larvae had destroyed all the green foliage available and had escaped, except one which was living in a tunnel 5 inches long through the center of a twig. This larva was feeding in the laboratory on the surface of leaves on July 29, but subsequently died on Aug. 8. Two larvae which hatched July 2 in the laboratory, were fed entirely on foliage and spun up July 24 and 27. From the readiness with which the larvae under observation have subsisted on tender foliage and sprouts we believe there is no question but that the larvae may sometimes mature on them.

On July 1 and 2, 1908, Mr. Jackson placed freshly hatched larvae upon apples and watched their first feeding habits incidental to securing the length of time the larvae remained in the apple. His observations show that most individuals entered the calyx within a minute, but that occasionally one will wander around for some time, even as much as an hour, before entering the calyx. When a gash was cut in the side of an apple the larva at once entered it. All the larvae crawled aimlessly about until reaching some such protection as the overhanging calyx lobes. The younger the larvae, the longer they wander about before finding a place to enter the apple. The older larvae would at once cut through the calyx lobes into the calyx cavity, entering the upper or lower calyx cavity, or crawl up over the lobes and down into the calyx cavity. The younger larvae might come to the calyx a number of times and leave again. All larvae fed in or around the calyx cavity for some time. It was evident from the readiness with which the young larvae fed on foliage, and the aimless manner in which they crawled around on the smooth surface of the apple, that the foliage is the normal food of the young larvae before they enter the ap-

ples. These observations were first made personally by the writer in 1906, and have been confirmed by his assistants in 1907 and 1908. Any disturbance of the newly hatched larvae seems to be quite hazardous, as those disturbed usually die.

FIG. 24.—The young apple worm feeding in the calyx cavity of the apple.

Place of Entering Apple. Previous investigations have shown that the great majority of the larvae enter the apples at the calyx end. Tables 15, 16 and 17 give the percentage of larvae entering at the calyx and side (including stem) for both first and second broods. The nine orchards in which records were kept show a variation of from 39 to 77 per cent. of the first brood entering the calyx on unsprayed trees, with an average of 65 per cent., while of the second brood from 22 to 79 per

cent. enter the calyx, averaging 46 per cent. The cause of so many more larvae of the second brood entering the side rather than the calyx is rather obscure, but seems to be related to the size of the second brood there being less injury through the calyx with a small second brood. Simpson gives an average of 81 per cent. of the first brood entering the calyx; Ball finds 66 per cent. of the first and 60 per cent. of the second broods entering the calyx in Utah; and Petit gives 70 per cent. of the first and 65 per cent. of the second broods as entering the calyx. These average 72 per cent. of the first brood, which is not far from the average we secure here, with rather a larger amount of data than any of the previous writers.

Length of Time in the Apple. In 1906 record of the time seven larvae were in apples was secured by placing an egg just ready to hatch in the calyx of an apple and covering it with a cheese-cloth bag, and then noting the time of emergence of the larva. The time in the apple was thus determined quite accurately, under normal conditions. The seven averaged 31.8 days. In 1907 the same method was employed, but not as successfully, the records of only four being secured, which averaged 34 days. In 1908 the larvae were placed on apples as soon as hatched and the time of their entering the apple was noted, but the apples were kept in the insectary room and were not under normal conditions. Under these conditions ten larvae averaged 24 1-2 days in apples. The temperature conditions in the room were practically the same as out of doors. These observations would indicate that from 25 to 30 days are usually spent in the apple in this region. Simpson records observations on four larvae in Idaho and of four in Colorado by Gillette which average 19 days, and quotes LeBaron as giving the time as four weeks; Riley, 25 to 30 days; Slingerland, 20 to 30 days; Card, 10 to 14 days; and Cordley, 16 to 24 days.

Time of Forming Cocoon. Some of those larvae which emerge first pupate and emerge as a small partial second brood of moths. Our breeding records are not as satisfactory on this point as might be desired, for in 1906 and 1908 we were unable to secure any pupae from bands placed on trees, while in 1907, a season which was two weeks later, 20 pupae were secured. It may be that the bands were applied too late in 1906 and 1908, but this seems hardly probable, as the progeny of the first moths to emerge could hardly mature much before Aug. 1. Each season several trees have been banded and the larvae collected at frequent intervals. In 1906, 30 trees at Bayside, Greenland, N. H., were examined and showed as follows:

1906.	Aug. 18,	25.	Sept. 6.	14.	Oct. 10.	
	0	15	21	8	28	Total, 72.

Sixty-six trees in the orchard of Albert DeMeritt at Durham, were also examined and showed the following:

July 28.	30.	Aug. 1.	2.	23.	27.	Sept. 1.	8.	12.	15.	Sept. 26 to Oct. 2.	Oct. 11.
2	1	1	3	22	24	21	16	17	15	209	74
										Total, 397.	

In 1907 the nine unsprayed trees in Gilman Woodman's orchard at Durham were examined with the following results:

Aug. 8-9.	Aug. 15.	Aug. 19.	Aug. 19.	Sept. 21.	May 13, 1908.	
24	40	13	150	312	84	
9 pupae						Total, 642.

In 1908 trees were examined in the same orchard as follows:

Date.	Aug. 1.	10.	12.	15.	18.	24.	Sept. 1.	3.	8-10.	14-17.
No. trees.	5	11	10	11	13	8	10	20	17	24
No. larvae,	12	22	25	22	28	18	20	79	43	63
Larvae per tree.	2.4	2	2.5	2	2	2¼	2	4	2½	2⅝

Second Brood. Observation in the orchard in 1906 showed the work of the second brood to be becoming noticeable about Sept. 6. In 1907, careful observations on the small trees tagged for securing the location of eggs, and on which the apples had been under constant observation, showed work of the second brood commencing Aug. 14. Sixteen pupae were connected under bands on Aug. 8 and 9, 1907, and three larvae subsequently pupated in the laboratory prior to Aug. 13. The moths emerged as follows: Aug. 12, 9; 14th, 2; 16th, 2; 17th, 1; 18th, 1; 20th, 2; 22d, 1; 23d, 1. The three which pupated in the laboratory emerged on the last three dates so that they could not have been in the pupal stage over 12, 14 and 15 days respectively. It seemed possible that the higher temperatures of midsummer might be responsible for the pupation of the first-maturing larvae. An experiment was therefore started Aug. 6, 1908, in which 120 apples, apparently containing worms, were placed in an incubator kept at about 82 degrees F. Up to Oct. 23, 33 of these larvae had died; one pupated Aug. 31, and emerged Sept. 10; one pupated Aug. 24, and emerged Sept. 2; two pupated Aug. 24 and one Sept. 8, and were still pupae, and the balance were still larvae, seventy larvae having emerged from the apples

up to Sept. 3, after which no more emerged. Thus, only 3 per cent. transformed, 7 per cent, pupated, 47 per cent. died and the balance remained larvae. Similar results have been secured in placing larvae in the greenhouse in winter, showing that the codling moth is influenced more by heredity or other unknown forces than by abnormal applications of temperature.

Attempts were made to secure eggs from the second brood of moths, but without success, nor have we been able to secure any data in regard to the place or number of eggs of the second brood in the orchard, although considerable time has been spent in search of them. That the larvae of the second brood may become full grown and pupate was shown by Dr. Headlee in 1906. On Sept. 5, 1906, he placed three larvae in the first instar in the calyces of three apples and bagged them. On Oct. 10 these were found to have merged and spun up cocoons, being apparently full grown. Five or six other apples upon which larvae were similarly placed became wormy, but the larvae escaped. Late in the season there always appear under the bands a number of half-grown larvae which form cocoons, but from none of which have we ever secured moths the next spring. Thinking that such partly grown larvae might feed in the spring, tender foliage was offered them, but without success. If it be true that the last larvae to hibernate are the last to transform to moths the next spring, as indicated in Table 3, then the individuals of the second brood of one year would give rise to those individuals which would mature latest the next season, and those larvae which mature too late to transform to a second brood, but the earliest to hibernate one year, will be the first to mature the next spring and will give rise to a partial second brood. It is evident from the band records cited above that not over 3 per cent. of the larvae maturing in a season transform to a second brood of moths, and probably not over 1 or 2 per cent.

EXPERIMENTS IN SPRAYING FOR THE CODLING MOTH.

Experiments in spraying for the codling moth have been conducted to determine the following points:

1. The relative value of different insecticides.
2. The amount of insecticide most profitable.
3. The best time or times to spray.
4. The best method of spraying.
5. How the spray kills the larvae.

The method of treatment of each orchard is fully outlined below, but the results are discussed from the standpoint of the whole series of experiments, the detailed results of which may be found in tables 8 to 18.

Important points brought out by these experiments are (1) the absolute necessity of large plots similarly treated and the record of all fruit from a considerable number of trees in the centre of each plot, and (2) the separation of the sprayed from the unsprayed plots by a barrier plot which is given the most thorough spraying. A few years ago the writer gave a summary of the previous spraying experiments* against the codling moth and pointed out that experiments upon but one or two trees, were of practically no value on account of the fact that the variation between two trees similarly treated will be greater than between those given different treatments. Our experiments in 1906 in the DeMeritt orchard showed that the average of five trees, similarly treated, will not give a fair basis for the determination of the efficacy of the treatment given if they adjoin untreated trees, or if in a certain portion of the orchard numerous trees bore fruit the previous year while the others had no crop, and thus gave rise to more moths in one part of the orchard than another. All of our experiments also show that to secure results which are comparable, the amount of fruit per tree must be fairly even for the whole orchard, it being impossible to secure any accurate basis of comparison between trees having large and small crops.

The experiments in the DeMeritt orchard in 1906 was a practical failure as regards giving comparable results for most of the plots owing to the arrangement of the plots, which were laid out as shown in figure 24. On either end of the sprayed plots were a few trees which had borne fruit the previous year but

*13th Annual Report Del. Agr. Exp. Station, pg. 184, tables VII, VIII.

had none in 1906. The Baldwin apple has a habit of bearing but every other year, and practically all of our experiments have been on this variety. As a result the trees near those which had borne the previous year, showed much more injury by the first brood than those at the centre of the sprayed plots more distant from them. See table 15, plots 11-15, 16-20, and 51-55, column 6, under First Brood, "Benefit as Total Per Cent Benefit," which show only 20 per cent., 5 per cent., and 17 per cent., respectively, against an average of 50 per cent. benefit in the other plots as regards the benefit to the first brood. Furthermore, as no barrier plot had been laid off between the unsprayed check trees and the balance of the orchard, which was unsprayed, and the sprayed portion, the moths of the second brood migrated to the sprayed trees and those plots nearest the unsprayed portion showed very little benefit to the second brood, whereas the benefit increased with the distance from the unsprayed trees. See table 15, plots 51-55, and 46-50, in column 4 under second brood.

Remembering the suggestive paper of Dr. S. A. Forbes, in which he showed the influence of the unsprayed plots upon the sprayed plots by permitting the multiplication and migration of the plum curculio, we determined that in making future experiments we would leave one end of the orchard unsprayed for checks, spray several rows across the orchard next to the checks in the best possible manner, calling this portion of the orchard the barrier plot, and would then lay off our plots at right angles to this barrier plot so that the influence of its effect upon the sprayed plots would be equal in all of them. Happily at this time the writer met Prof. A. L. Quaintance of the Bureau of Entomology, to discuss methods of work upon this subject, and it is to him that I am indebted for the suggestion that we make our plots three rows wide and count only the middle row, thus having 15 trees in each plot, the outer rows of which tend to reduce the influence of one plot on another. Our work in 1907 showed not only the absolute necessity for such an arrangement. but that it would be wise to go even further and have the plots contain 35 trees each, 5 rows wide and 7 rows long, and count the central five trees, so as to better reduce the influence of the neighboring plots. It is of the utmost importance in making an experiment to give any exact results on the codling moth, that the trees be of a uniform size, fruit evenly, and have borne approximately the same the previous year. A few trees scattered thru an orchard which have borne the previous year when the

balance of the orchard did not, will seriously affect the results of the work the following season. From careful study of our records it is evident that too much importance cannot be placed upon the ground plan of such an experiment, and that experiments based on individual trees scattered thru an orchard are of little value in trying to determine the amount or nature of the effect of spraying upon the different broods of the codling moth. Furthermore, at least five trees must be counted in each plot isolated as already described by surrounding trees similarly treated, and preferably 10 trees should be counted, for it will be found that the records of five individual trees will vary fully as much as the average of one plot and another.

In 1908 the fruit crop was so light that we were compelled to arrange our plots as best we could, and although it was entirely impossible to follow the above plan, we followed the principles as closely as possible.

The results of the three years' experiments are not as conclusive in answering the questions we had propounded for their answer, as we might wish. It is evident, however, that with the small orchards available for work, the uneven fruiting, and fruiting mostly on alternate years, that it will be impossible for us to secure any more accurate results unless the experiments were carried on for a very much longer series of years than the importance of the questions still to be answered would warrant. The main problems of practical importance and the life history of the insect for this region have been worked out. Were it not so evident that further field experiments would give equally unsatisfactory results under the orchard conditions available for such work, we should continue the experiments until some of the questions of the effect of the spray on the larvae were more definitely determined. That there is opportunity for some excellent work along this line where large orchards, evenly fruited, bearing annually, can be secured for work, is evident, and it is hoped, that the work of the writer may be suggestive of methods for the prosecution of such work.

Experiments in 1906.

Orchard of H. H. Thompson, Walpole, N. H.

This orchard is located about three miles north of Walpole, N. H., and consists of large bearing trees probably 30 years old, along the roadside and in a scattering orchard. The trees treated similarly were adjacent to each other, but there were no definite plots of trees as in 1907. A plan of the orchard would

be of no particular value in interpreting the results. All trees were sprayed twice. The first spraying was given June 2 when the calyces had barely commenced to close and were still well opened. The second spraying was given June 8 when the calyces were pretty well closed, tho many were still fairly well open. The spraying was done with an Eclipse barrel pump and Vermorel nozzels. Trees 1, 2, 3 were Baldwins sprayed with Paris green 1-4 lb. to 50 gallons of 5-5 Bordeaux mixture. Trees 4, 5, 6 were Baldwins not sprayed, used as checks. Trees G1, G2, G3 were R. I. Greenings sprayed with arsenate of lead (Eagle brand) 1 lb. per barrel of 5-5 Bordeaux mixture. Trees G4, G5, G6 were Greenings, sprayed with Paris Green, 1-4 lb. to 50 gallons 5-5 Bordeaux mixture. Trees G7 and G8 were Greenings not sprayed, used as a check.

It should be noted that the calyces were much more open in this orchard than in Prof. Hooper's orchard, which is given below. Severe russetting resulted from the spraying with the Bordeaux mixture thruout the orchard.

Orchard of Prof. F. W. Hooper, Walpole, N. H.

This orchard consists of about 100 trees of various varieties, a number of McIntosh Red and Baldwin trees, being about 20 years old, and with a decided southern exposure. The trees in the various groups are adjacent to each other and arranged in rows; but only the numbered trees were so treated, there being no plots as in 1907. Eclipse pump and Vermorel nozzles were used. The first spraying was given on June 2. The calyces on trees 1-8 McIntosh and Winter Pearmain were pretty well closed at this time tho the Baldwins were fairly well open. The second spraying was made June 8 when the calyces were practically closed on all but the Baldwins.

Treatment: Trees 1-4, McIntosh Red, Paris green, 1-4 lb. to the barrel of 5-5 Bordeaux mixture. Trees 5-8, Winter Pearmain, 1-4 lb. green arsenoid to 1 barrel 5-5 Bordeaux mixture. Trees 9, 11, 12, 13, Baldwin, 1-4 lb. Green Death to a barrel 5-5 Bordeaux mixture. Trees C1, C2, C3, McIntosh Red, unsprayed. Trees C4, C5, Winter Permain, unsprayed. C6, C7, C8, Baldwin, unsprayed.

It should be noted that on many of the trees the calyces were practically closed when the spraying was done owing to the orchard having a southern exposure and being much earlier than Mr. Thompson's. The decided difference in the results may be accounted for from this fact.

Orchard of C. E. L. Hayward, Hancock, N. H.

This orchard consisted of about 200 Baldwin trees about 15 years old, almost all of them bearing and in a vigorous, thrifty condition, located on a hilltop. The trees of the different groups were adjacent to each other, but only the numbered trees were sprayed as described. The sprayed trees were located in four adjacent rows forming a solid block.

The first spraying was given May 31, when the petals had just fallen, the apples being in exactly the right condition for spraying. The second spraying was given June 8 when the calyces were closing. The spraying was done with an Eclipse barrel pump and Vermorel nozzles.

Treatment: Trees 1-5, first spraying, 1 lb. Eagle arsenate of lead, and the second spraying 1 1-2 lbs. Target arsenate of lead per bbl. Trees 6-10, first spraying, home-made arsenate of lead made with 4 ounces arsenate of soda and 11 ounces acetate of lead per barrel; second spraying, trees 6-8 sprayed in the same manner, trees 9 and 10 unsprayed. Trees 12-16, first spraying 1 lb. Target arsenate of lead per barrel; second spraying, 1 1-2 lbs. Swift's arsenate of lead per barrel. Trees 11, 17-20, first spraying, 1 lb. Swift's arsenate of lead per barrel; second spraying, 1 1-2 lbs. Eagle arsenate of lead per barrel. Tree 21, first spraying, Swift's arsenate of lead 1 lb. to the barrel; trees 22-25, first spraying, 1 1-2 lbs. Disparene per barrel; trees 21-25, second spraying, 1 1-2 lbs. Disparene per barrel. The arsenate of lead was added to 5-5 Bordeaux mixture in all cases.

The object of the experiment was to give a field comparison of different brands of arsenate of lead, but owing to the confusion in putting the brands on the same plots at the time of the second spraying, this was prevented in all but trees 6-8 sprayed with home-made arsenate of lead, as contrasted with trees 22-25, sprayed with Disparene. About 3 gallons of mixture was used per tree. Subsequent experiments show that it is decidedly doubtful whether a field test of arsenates of lead of approximately uniform grade, will show any decided difference in the result and no further experiments have been made along this line as it has seemed to the writer impracticable to secure accurate comparisons in the field which could be certainly attributed to the difference in the various brands. Great benefit would have been secured in this orchard if more mixture had been used. Subsequent experience shows that 5 gallons should probably have been used where but 3 were used.

Orchard of William Weeks, Greenland, N. H.

This orchard consisted of two or three hundred Baldwin trees, 40 or 50 years old, near Bayside station. The trees bearing fruit were scattered thru the orchard and were practically all used in the experiments. Trees in the various groups were adjacent to each other but no large plots were treated as in 1907. Six groups of 4 trees each were sprayed as follows: Trees 1-4 1 lb. arsenate of lead per barrel 5-5 Bordeaux mixture. Trees 5-8, Bowker's Dust Bordeaux (copper phosphate), 15 lbs. per barrel (1 1-2 lbs. lime added to counteract free copper by ferrocyanide test). Trees 9-12, Pyrox, 8 lbs, per barrel. Trees 13-16, Target Quick Bordeaux 10 lbs. per barrel and 1 lb. arsenate of lead. Trees 17-20, 1 lb. arsenate of lead to 10 lbs. Leggett's Dry Bordeaux. Trees 21-24, 1-4 lb. arsenate of lead to 1 gallon Lennox Concentrated Bordeaux mixture per barrel. The arsenate of lead was Swift's made by the Merrimac Chemical Co The object of the spraying was to secure data as to the comparative effect of Pyrox with arsenate of lead, and various prepared Bordeaux mixtures with the home-made Bordeaux, upon apple scab, but so little scab developed that no results of positive value were secured. Unfortunately, the records of the picked fruit were lost in the case of all but 4 trees, which are given in Table 19, but inasmuch as all were treated with the same amount and kind of arsenate of lead they form a fair basis for comparison with the unsprayed trees.

The first spraying was given May 30 when almost all the petals had dropped from the trees. The second spraying was given June 11 when the calyces were partially open but were nearly closed.

The results of this orchard are particularly interesting in showing the benefit derived from spraying in a badly infested orchard.

The record of the picked fruit from a commercial standpoint, is of interest in this orchard, as care was taken to secure the amount of fruit from sprayed and unsprayed trees when it was graded and packed. The sprayed trees picked 3.2 barrels per tree, of which .75 barrels was No. 1 fruit and 2.45 barrels No. 2 fruit. The unsprayed picked 1.8 barrels per tree, of which .4 barrel was No. 1 fruit and 1.4 barrel was No. 2 fruit, the grades one and two being used in the exact sense as defined by the National Apple Dealers Association. These figures would show that the spraying gave a benefit of 1.4 barrel picked fruit per tree, or 44 per cent., of which .35 barrels per tree was No. 1

fruit, giving a benefit of 46 per cent, for No. 1's; and 1.05 barrels was No. 2 fruit, giving a benefit of 41 per cent. for No. 2 fruit. The actual price paid for this fruit in the orchard was $1.00 per barrel on the tree, so that the actual benefit from the spraying, as shown by the difference in the amount of picked fruit between the sprayed and unsprayed trees, was worth $1.40 per tree.

Orchard of Albert DeMeritt, Durham, N. H.

This orchard consists of about 150 Baldwin trees about 35 years old, and located as shown in figure 25. The trees sprayed were adjacent to each other as shown in figure 25, but no surrounding trees were similarly treated so as to form plots, as in 1907. The first spraying was given May 30 when the blossoms had just dropped, there being still about 25 per cent. of the petals on the trees. The second spraying was given June 8 and 9, when the calyces had barely closed. A third spraying was given June 21. The fifth spraying was given Aug. 30. The trees were sprayed with an Eclipse pump and Mistry nozzles. The first spraying was given during a strong breeze; the trees are high and undoubtedly many parts were not thoroughly covered. About 2 1-2 gallons of mixture were used per tree, which is entirely too small an amount, as subsequent experience has shown. Eagle brand arsenate of lead was used in this experiment, analysis of which shows, page 435, a very low content of arsenic.

Treatment. Trees 11-15, arsenate of lead 1 lb. to 50 gallons of 5-5 Bordeaux; first spraying only. Trees 16-20, 1 lb. arsenate of lead per barrel 5-5 Bordeaux mixture first spraying and 1 lb. arsenate of lead per barrel of water, 5th spraying. Trees 21-25 given first and third sprayings with K. L. B. P., made with Bordeaux and Paris Green. This was made to contain 15 per cent. kerosene and 1-3 lb. Paris Green per barrel of 5.5 Bordeaux. Trees 26-30 given sprays 1 and 2 with K. L. B. P., made the same as for trees 21-25. The actual ingredients used being 5 lbs. lime 1 1-4 gallons kerosene, 11 gallons 5-5 Bordeaux mixture, 1 1-3 ounces Paris green. Trees 31-35 given first and second sprayings with Paris green 1-3 lb. per barrel of 5-5 Bordeaux. Trees 36-40 given first and second sprays with 2-5 lb. Paris green per barrel of 5-5 Bordeaux mixture. Trees 41-45 given first and second sprayings, 2 lbs. of arsenate of lead per barrel of 5-5 Bordeaux mixture. Trees 46-50 given first and third sprayings with arsenate of lead 1 lb. per barrel of 5-5 Bordeaux mixture. Trees 51-55 given first two sprayings, 1 lb. arsenate of lead per barrel 5-5 Bordeaux mixture. Trees 56-60 given third

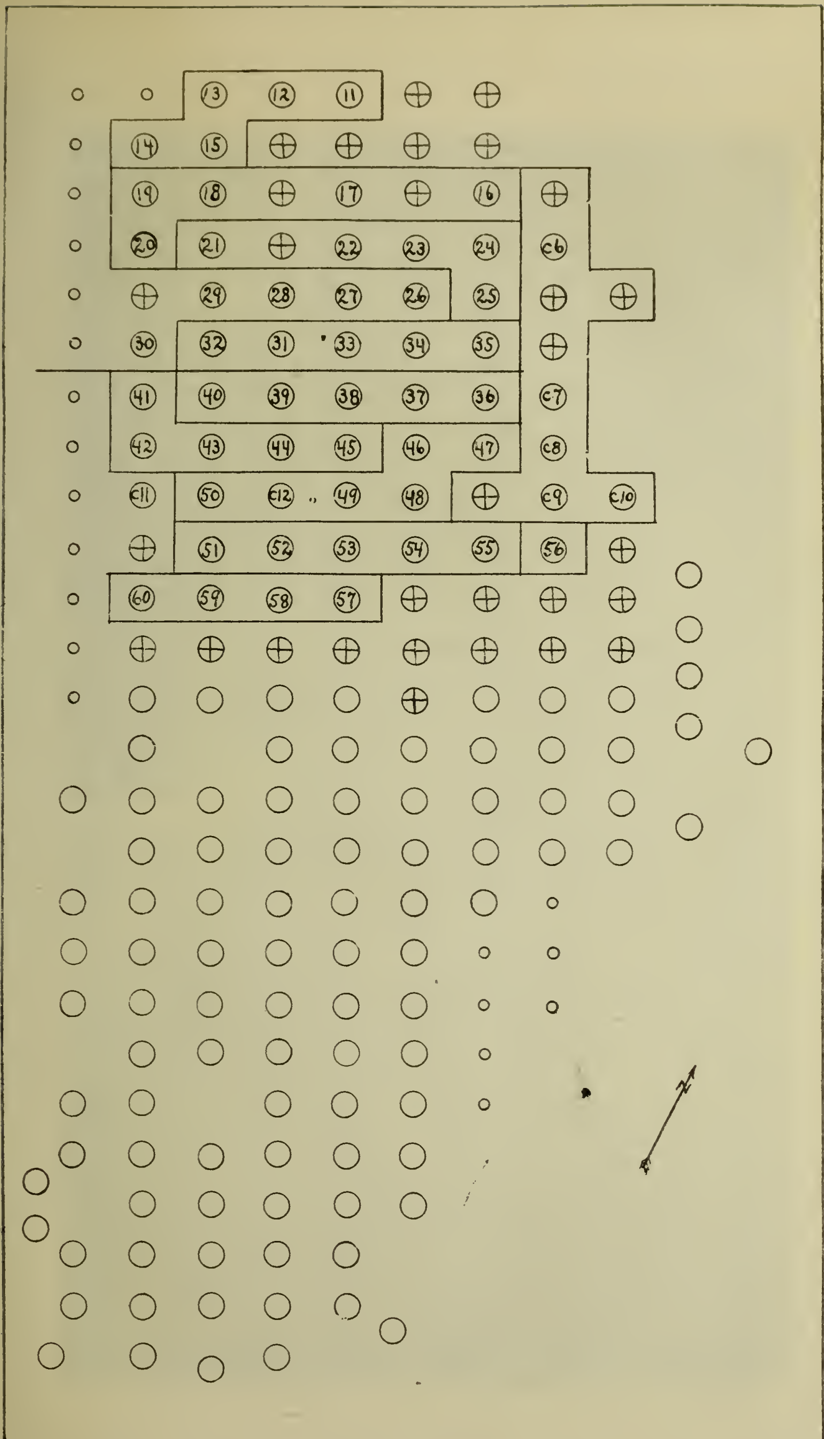


FIG. 25.—Diagram of orchard of Albert DeMeritt, Durham, N. H., used in experiments in 1906. Circles represent trees. Circles with crosses are trees which bore in 1905, but bore practically no crop in 1906. Solid lines show boundaries of sprayed plots; remainder of orchard unsprayed.

spraying only, arsenate of lead 1 lb. to 50 gallons 5-5 Bordeaux mixture. At the third spraying, trees 46, 47, 56 and 58 were specially sprayed on the under surface of the foliage, but no difference could be found between these trees and the others upon comparing the results for the season.

Considerable russetting of the fruit resulted in this orchard. Those given the first spraying only were russetted nearly as badly as those sprayed twice. Those sprayed with the K. L. B. P. were not russetted as badly as those sprayed with plain Bordeaux. Trees given the first and third sprayings were not as badly injured as those given the first and second spraying. Trees given the third spraying only, were but slightly russetted.

The results of the spraying in this orchard are discussed below. It should be pointed out that the southern half of the orchard was entirely unsprayed, and it is very evident that the sprayed trees adjoining the unsprayed portion were more seriously injured by the second brood.

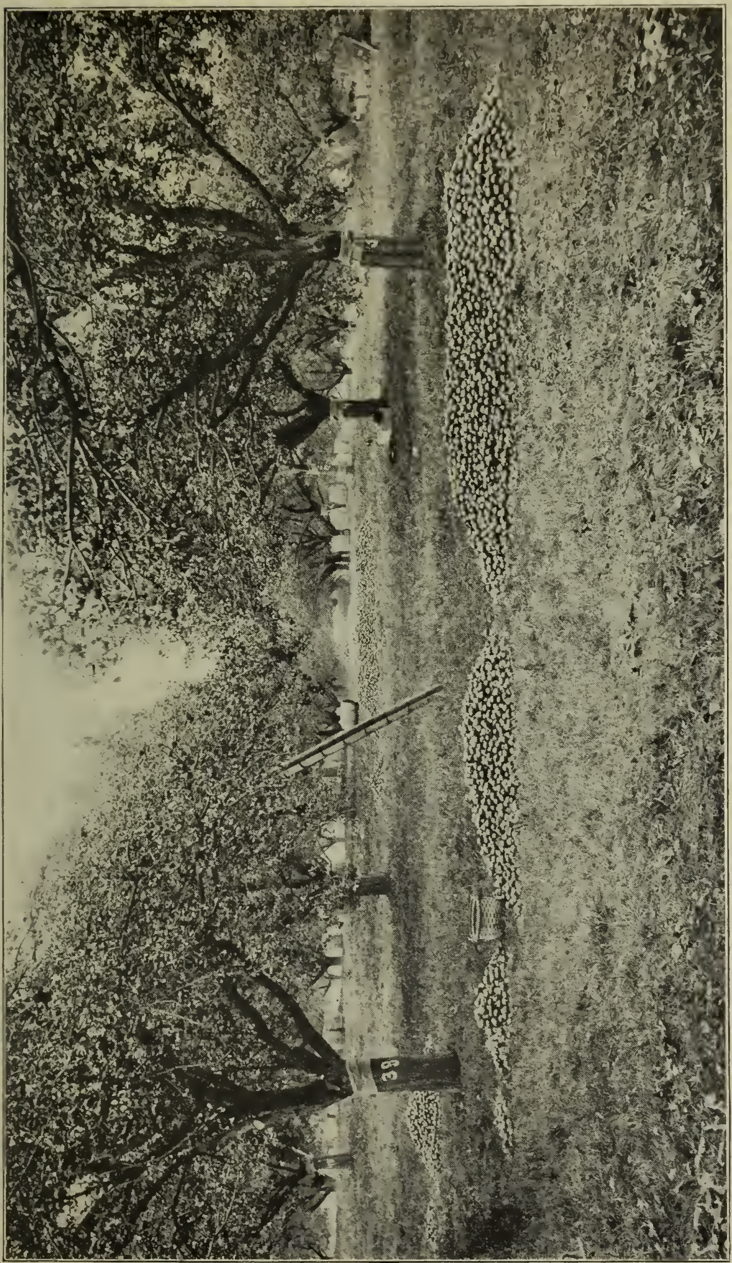
It should also be noted that in this orchard the trees bearing in 1906 probably did not bear any considerable crop in 1905, whereas the trees that bore in 1905 bore nothing in 1906. The sprayed trees next to those trees which bore in 1905, as indicated in figure 25, seem to show less benefit from this spraying, and probably were more infested.

The results in this orchard point very closely to the desirability of arranging such experiments in plots as were used in our experiments in 1907.

Experiments in 1907.

Orchard of Gilman Woodman, Durham, N. H.

This orchard consists of Baldwin trees about 30 years old, located as shown in fig. 26. Some old scattering trees run along the walls of the farm, but otherwise there are no orchards within a half mile. To obviate the influence of one plot on another and of the check trees on the treated trees, the orchard was laid out in plots as shown in fig. 26, with the idea of counting only the five trees of the middle row of each plot. In plots 1 and 2 the outer row was counted. Plot 4 was treated in different ways, all of the trees being counted. The rows of barrier trees, thoroughly sprayed, prevent any influence from the check plot upon the treated plot, as the results seem to show. The dates of the spraying were as follows: First spraying, June 13, 14, when the majority of the blossoms had dropped; second spraying, June 25; third spraying, July 3 and



View in DeMeritt Orchard, Durham, N. H., 1906.

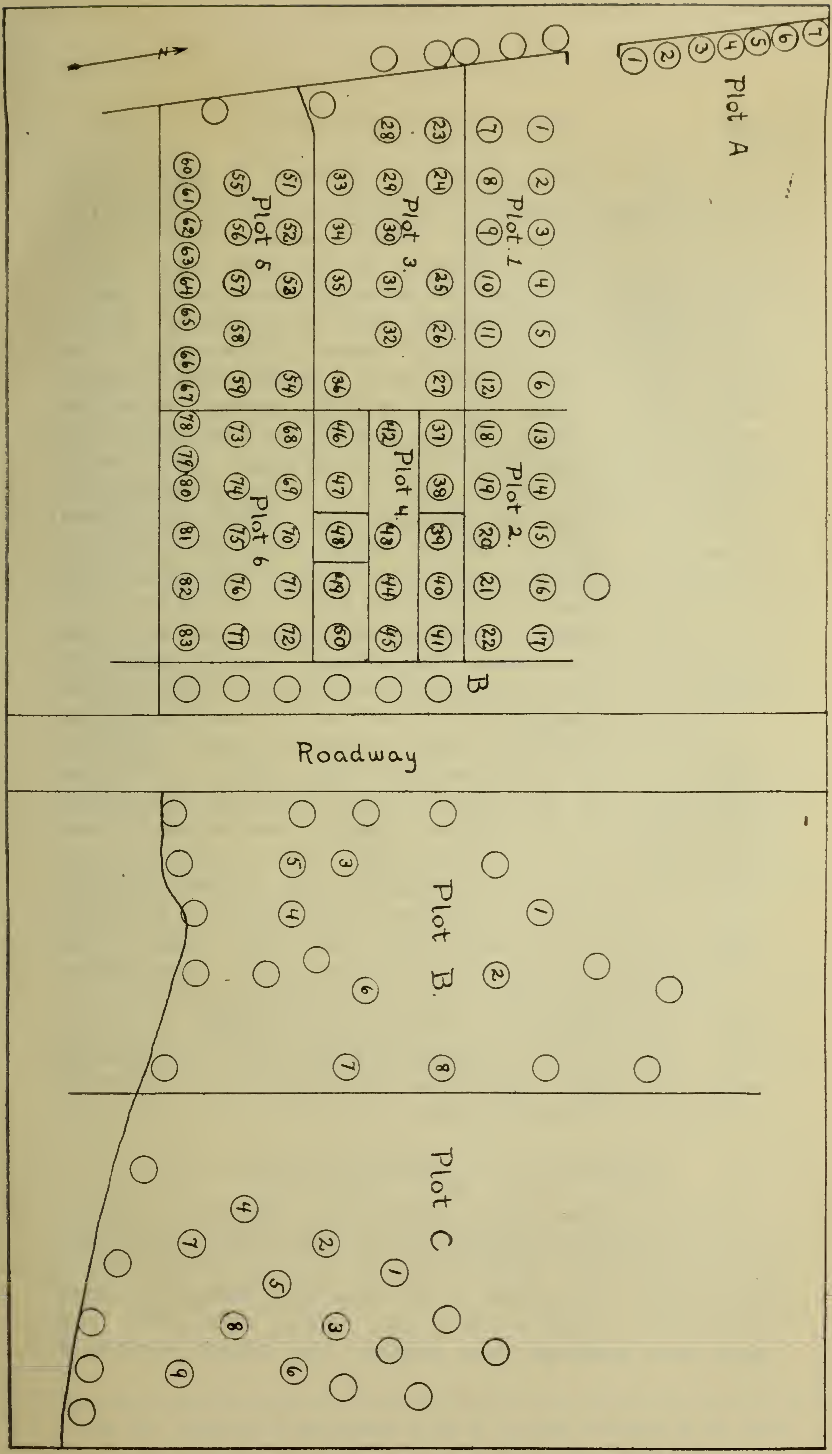


FIG. 26.—Orchard of Gilman Woodman, Durham, N. H., 1907.

4 and July 8. The spraying was done with an Eclipse barrel pump and Mistry nozzles with a pressure of not less than 80 lbs. as shown by pressure guage. Swift's arsenate of lead, 2 lbs. per barrel, was used on all plots, the use of Bordeaux mixture being discarded to obviate the danger of russetting the fruit.

The treatment of the various plots was as follows: Plot 1, given first spraying with Mistry nozzles, third spraying in the usual manner. Plot 2, given spray 1 applied with Bordeaux nozzles giving a coarse spray at as high a pressure as could be secured with the pump, and the spraying was kept up until the mixture ran from the trees. Plot 3, given sprays 1 and 3, using the Mistry nozzles. Plot 4A, trees 39, 40, 41 were given the third spraying in the usual way. About 7 gallons of spray was applied to each tree. Plot 4A, trees 37 and 38, were given the third spraying with the addition of 3 lbs. of Good's resin fish-oil soap to the 2 lbs. of arsenate of lead, per barrel. Plot 4B, given the first spraying applied to the calyces with a nasal atomizer so that the foliage was not sprayed. Plot 4C, trees 46 and 47, given third spraying, the foliage being sprayed from both above and from below by men on the ground. Plot 4C, tree 48, was given a third spraying from above and below, but before spraying all of the apples were covered with small paper bags, which were removed immediately after the spraying, so that the foliage was sprayed but the apples were untouched. Plot 4C, trees 49 and 50, were not bearing and were left untreated. Plot A, consisting of a row of trees along a wall separate from the orchard, was given sprays 1, 3 and 5, the latter being applied about the middle of August, when it was thought the eggs of the second brood would have been deposited. Plot B, was given the first, second and third sprayings, the bearing trees being sprayed with Bordeaux nozzles until they dripped freely, the same as plot 2. Plot 5 was given the second spraying only. Fine cap Vermorel nozzles were used. Plot 6 was given spray 3 only with small aperture triple Vermorel nozzles.

Orchard of W. A. Deering, Pittsfield, N. H.

This is a young orchard of about 275 trees about 17 or 18 years old. The four outside rows on each side were top worked to McIntosh Red. Plots 13, 14, 15 were mostly Ben Davis, while plots 8 to 12 were trees which were partially Baldwin and partly McIntosh Red. The trees were small and there were numerous trees missing. The orchard bordered a

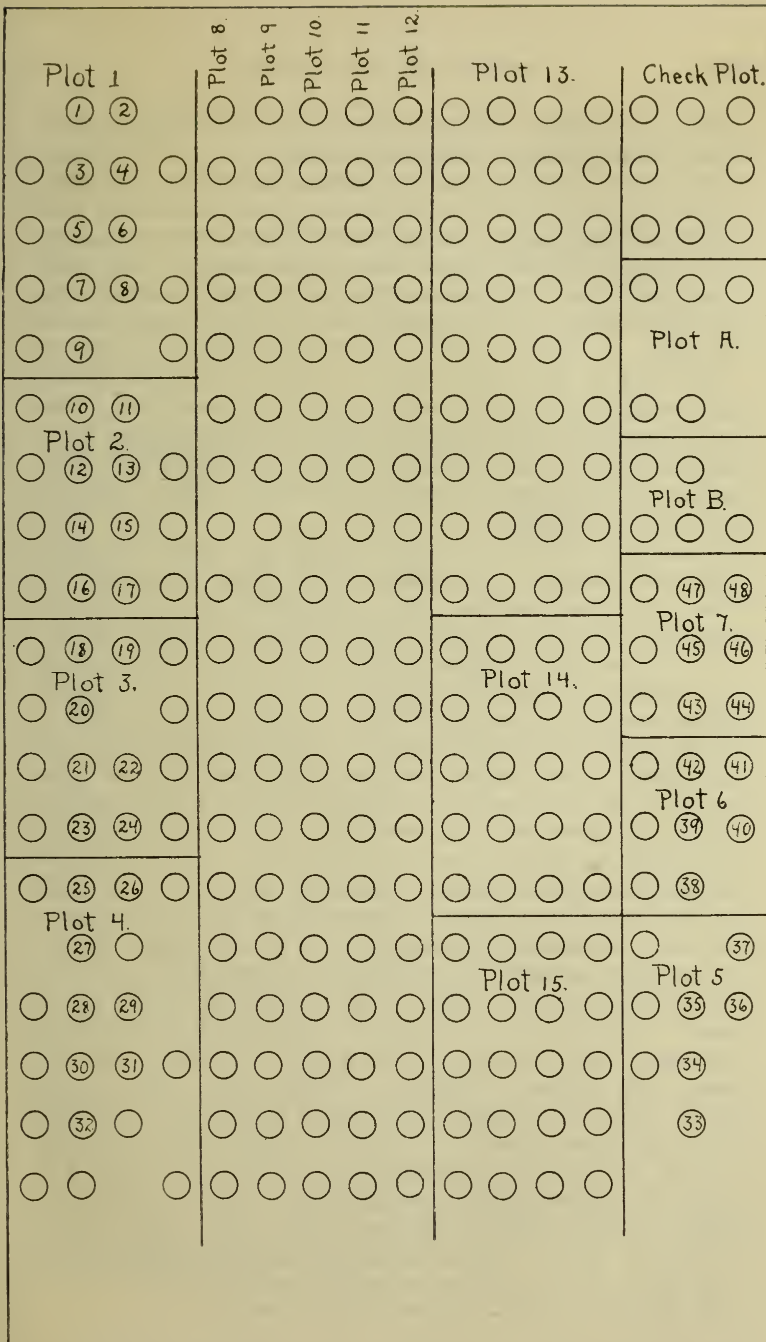


FIG. 27. Diagram of the orchard of W. A. Deering, Pittsfield, N. H., 1907.

road on the south, beyond which was an old orchard which would form a natural source of infection.

The dates of spraying for the codling moth were as follows: The first spraying June 17 and 18, when the blossoms had practically all fallen and on some of the McIntosh trees the calyces were about one-half closed. The second spraying was made June 29. The third spraying was given July 11 and the 5th spraying August 16. A spraying with fungicides was given on May 20.

The plan of the plots is shown in Fig. 27, all trees in each plot being treated in the same way, but only the central trees being recorded. The spraying was done with an Eclipse pump, and Mistry or Spramotor nozzles, except where otherwise noted. 2 lbs. Swift's arsenate of lead per barrel was used on all plots not otherwise specified.

Treatment. Plot 1 was given the first and second sprayings with the arsenate of lead added to 3-4 Bordeaux mixture and applied with Mistry nozzles. Plot 2 was given the first and second sprayings with arsenate of lead added to 3-4 Bordeaux mixture, applied with Bordeaux nozzles, with 90 to 100 lbs. pressure, until the trees dripped freely. Plot 3 was given the first, second and third sprayings with the arsenate of lead added to 3-4 Bordeaux mixture, the first two sprayings applied with Mistry nozzles. Plot 4, given the first, second and third sprayings with 1-3 lb. Paris green per barrel of 2-4 Bordeaux mixture. Plot 5 was given the first, second and third spraying, the first two being the same as plot 4, but the third spraying consisting of kerosene-limoid mixture, containing 15 per cent. kerosene and 1-3 pound Paris green per barrel. Plots 6 and 7 were given the first and second sprayings with 1-3 lb. Paris green and 10 lbs. of copper phosphate per barrel, with enough fresh lime added to neutralize the free copper as shown by ferro-cyanide test on plot 7. Plots 8, 9, 10 and 11 were given the first and second sprayings with arsenate of lead added to Bordeaux mixture, made with sodium benzoate in various ways. Plot 12 was given the first and second sprays with arsenate of lead added to 3-4 Bordeaux mixture. Plot 13 and the north row of plots 14 and 15, were given the first, second and third sprays with arsenate of lead without any Bordeaux. Plot 14, except the north row, was given the fifth spray only, with 2 lbs. arsenate of lead per barrel. Plot 15 except the north row, was given the fifth spray only with 2 lbs. arsenate of lead per barrel to which was added 3 lbs. of Good's resin fish oil soap.

Plot B, barrier plot, was given the same treatment as plot 3, namely, the first and second sprayings with arsenate of lead added to 3-4 Bordeaux mixture. Plot A was given the first and second sprayings with Bordeaux mixture, only, without arsenate of lead. Plot C was given no treatment and formed a check plot. Considerable russetting of the fruit resulted from the Bordeaux mixture throughout the orchard. Russetting resulted, even from the 2-4 Bordeaux mixture, and both on plots given only the first and only the third sprayings.

Orchard of Arthur Ladd, Deerfield, N. H.

The treated plots consisted of about 60 trees, forming the east end of an orchard about three times this size, situated on the crest of a high ridge. The balance of the orchard was mostly Mann apples. The trees treated were McIntosh Red, about 20 years old. The plan of the orchard treated is shown in Fig. 28. The trees were sprayed with a Myers pump and Mistry nozzles. The dates of spraying were as follows:

First spraying June 7, second spraying June 21. A previous spraying had been given with fungicides on May 17.

Plots A, B, C and D consisted of three rows of trees, all trees in each plot being given the same insecticidal treatment, but each of the three rows being sprayed with a different fungicide. 2 lbs. of arsenate of lead per barrel were in all cases added to the fungicide. All plots were given the first and second sprayings.

Plot A, row 2, was given the first spraying with Target brand arsenate of lead, and the second spraying with Swift's arsenate of lead added to Target Quick Bordeaux mixture, 10 lbs. per barrel. Plot B, row 5, was sprayed with Eagle arsenate of lead, 2 lbs. per barrel, added to Leggett's Dry Bordeaux mixture oxidized, 10 lbs. per barrel. Plot C, row 8, was sprayed with Target arsenate of lead, 2 lbs., added to Lion Bordeaux, 3 quarts per barrel. Plot D, row 10 sprayed with Target arsenate of lead, 2 lbs., added to copper phosphate, 15 lbs. per barrel. Plot E was sprayed with Pyrox, 5 lbs. per barrel. Plot F was sprayed witih arsenate of lead, 2 lbs. and 2-4 home-made Bordeaux mixture. Plot C was unsprayed and formed the check.

The work in this orchard and in that of J. T. Smith, was carried on under the supervision of Dr. Charles Brooks, the Botanist of the Station, throughout the season.

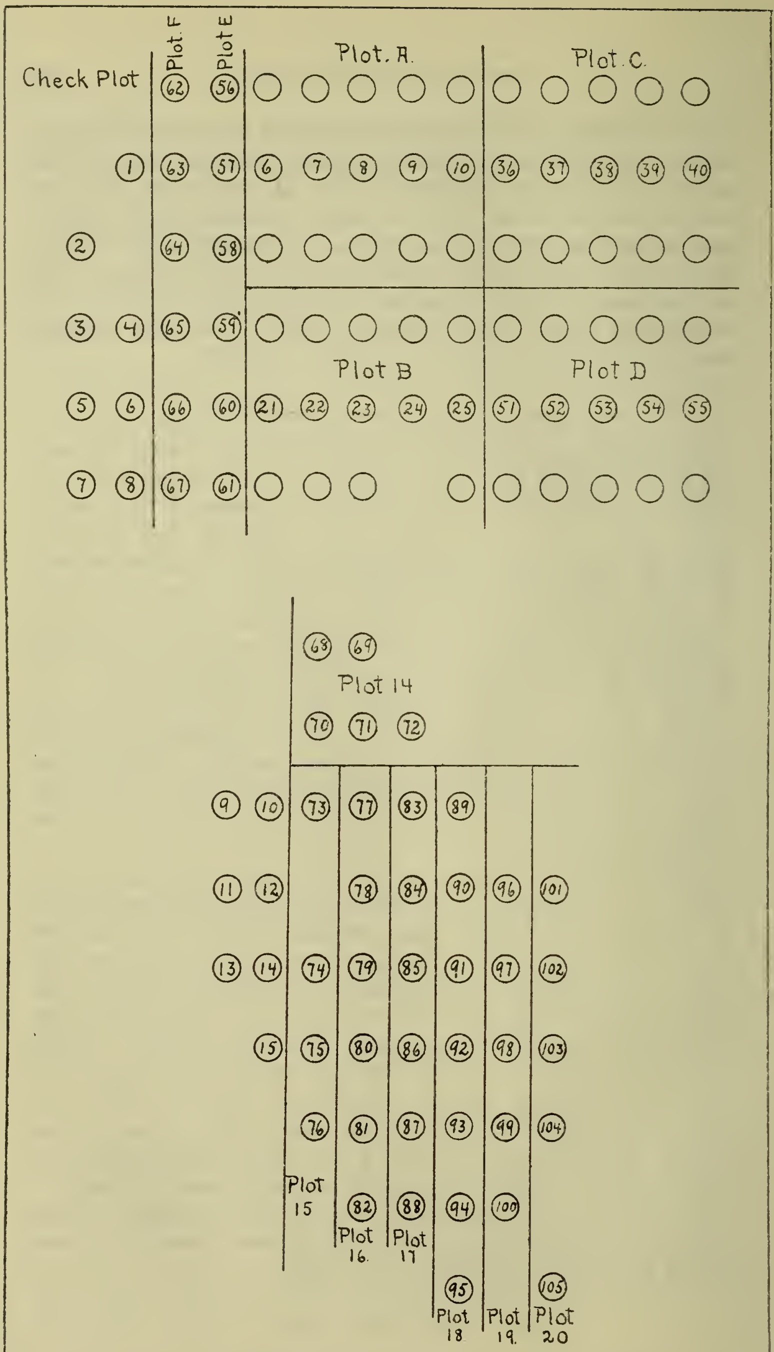


FIG. 28. Above: diagram of the orchard of Arthur Ladd, Deerfield, N. H., Below: orchard of J. T. Smith.

Orchard of Jonathan T. Smith, Deerfield, N. H.

This orchard consisted of McIntosh Red trees about 20 years old, arranged as shown in Fig. 28, immediately next to the owner's house. A small scattering orchard stood back of the barn across the road. The orchard sprayed was at the foot of a slope. Trees were sprayed with the same apparatus as used in Mr. Ladd's orchard and on the same dates.

Treatment. Plot 14 was given the first and second sprayings with 2 lbs. Disparene added to 4-4 Bordeaux mixture. Plots 15, 16, 17 and 18 were given the first spraying with 2 lbs. Disparene per barrel added to various strengths of Bordeaux mixture and the benzoate of soda Bordeaux, but the second spraying was made with fungicide only. Plots 19 and 20 were sprayed with fungicide only. The insecticide applications on the plots in the orchards of Mr. Smith and Mr. Ladd, were planned to show the relative value of different brands of arsenate of lead, but owing to misunderstanding they were not all applied as originally intended, though they furnish a basis for comparison of three brands and are of interest in showing the value of the first and second spray, as compared with the same in other orchards.

Experiments in 1908.

Orchard of Gilman Woodman, Durham, N. H.

The same orchard as used in the experiments in 1907 was arranged in plots as shown in Fig. 29, which were necessitated by the very few trees bearing, practically all of the bearing trees being utilized in the experiment. The spraying was done with a Niagara gas sprayer and Vermorel nozzles, unless otherwise specified, a pressure of 90 to 100 lbs. being usually maintained. The dates of spraying were as follows: First spraying, May 27-28; third spraying, June 22. The first spraying was given just after the blossoms had dropped.

Treatment. 2 lbs. Grasselli's arsenate of lead, per barrel, was used in all cases, without the Bordeaux mixture. Plot 1 was given the first spraying only, with 4 Vermorel nozzles, with fine apertures, so as to make a mist at 100 lbs. pressure, the trees being thoroughly sprayed. Plot 2 was sprayed with nasal atomizers from May 30 to June 6, the spray being directed into the calyces without placing any on the foliage. Tree 8 was gone over twice in this way. Plot 3 was given the first spraying only, but a

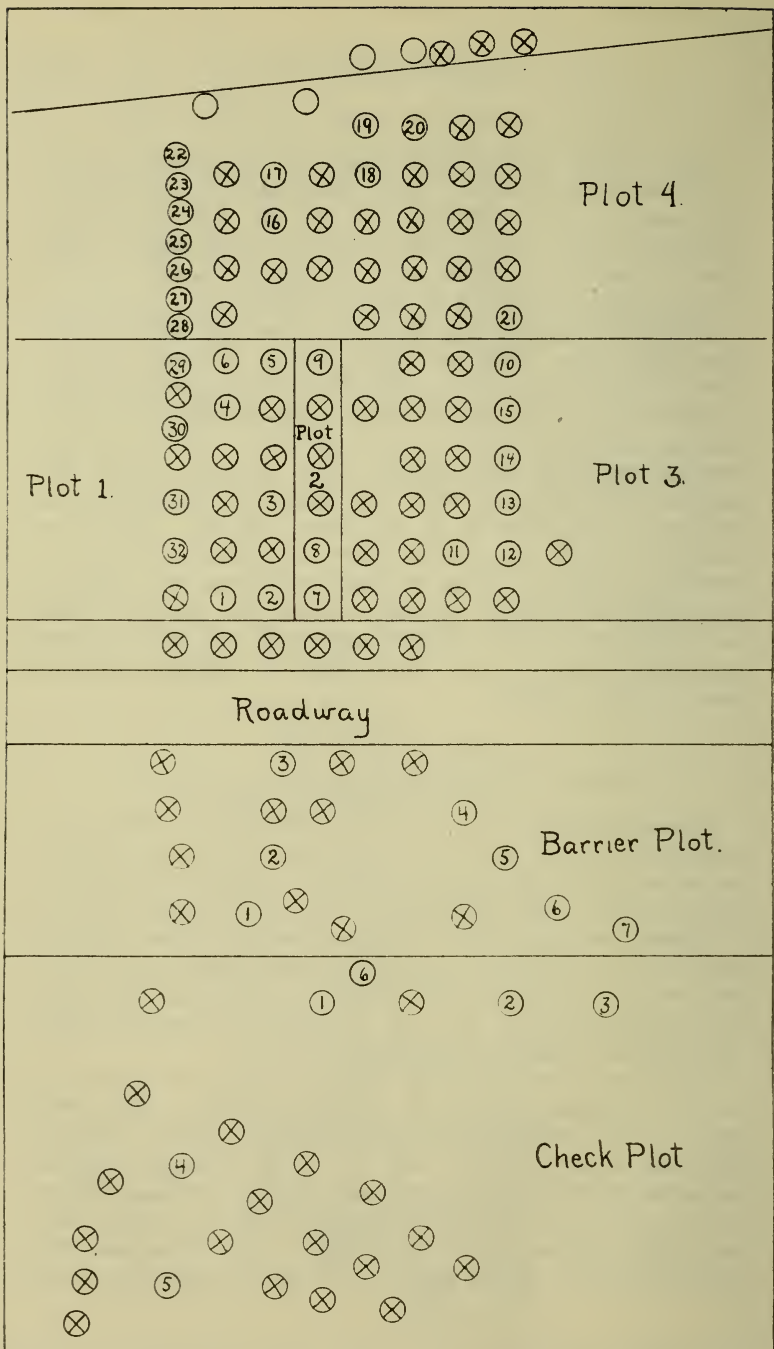


FIG 29. Diagram of the orchard of Gilman Woodman, Durham, N. H.

double Bordeaux nozzle with coarse spray was used, directed into the calyces and at a pressure of 110 to 120 lbs. The foliage was thoroughly drenched with 7 to 10 gallons per tree. Plot 4 was given the third spraying only. Plot B, barrier plot, was given the first and third sprayings. Plot C was unsprayed and formed the check.

Orchard of Albert DeMeritt, Durham, N. H.

The same orchard as used in the experiments of 1906 was arranged in plots, as shown in Fig. 30, the arrangement being necessitated by the very few trees bearing fruit. The southern part of the orchard remained unsprayed. Trees were sprayed with a gas sprayer and Vermorel nozzels, the first spraying being given May 28 and 30; the second spraying June 11 and the third spraying June 23.

Plot 1 was given the first and third sprayings, 2 lbs. Grasselli's arsenate of lead per barrel. Plot 2 was given the second spraying only, 2 lbs. Grasselli's arsenate of lead per barrel. The calyces were closed about June 6. Plot 3 was given the third spraying only, with 2 lbs. Grasselli's arsenate of lead. Plot B, barrier plot, was given the same treatment as plot 1. Plot C was unsprayed and formed the check plot.

Packers Falls Orchard, Durham, N. H.

This orchard is one leased by the Station from Mrs. S. J. Woodman for a term of years for experiments of the Horticultural Department, and consists of about 300 trees arranged as shown in Fig. 31. Another orchard lies to the west of this orchard at a distance of some 75 yards beyond Plot C. Trees were sprayed with a Niagara gas sprayer and Vermorel nozzles, except plot 1, where Bordeaux nozzles were used. Grasselli's arsenate of lead was used throughout.

The first spraying was given June 4 to 6; the third spraying June 26; the fifth spraying August 11. At the time of the first spraying the calyces were as nearly closed as would be possible and still permit effective spraying. This may partially account for the advantage shown by a drenching spray.

Plot 1 was given the first spraying only with 2 lbs. arsenate of lead, using Bordeaux nozzles with a drenching spray directed into the calyces with 110 to 120 lbs. pressure. Plot 2 was given the first spraying only, but with 4 Vermorel nozzles at about 100 lbs. pressure. Plot 3 was given the first spraying with 2 lbs. arsenate of lead and the third spraying with 10 lbs. per bar-

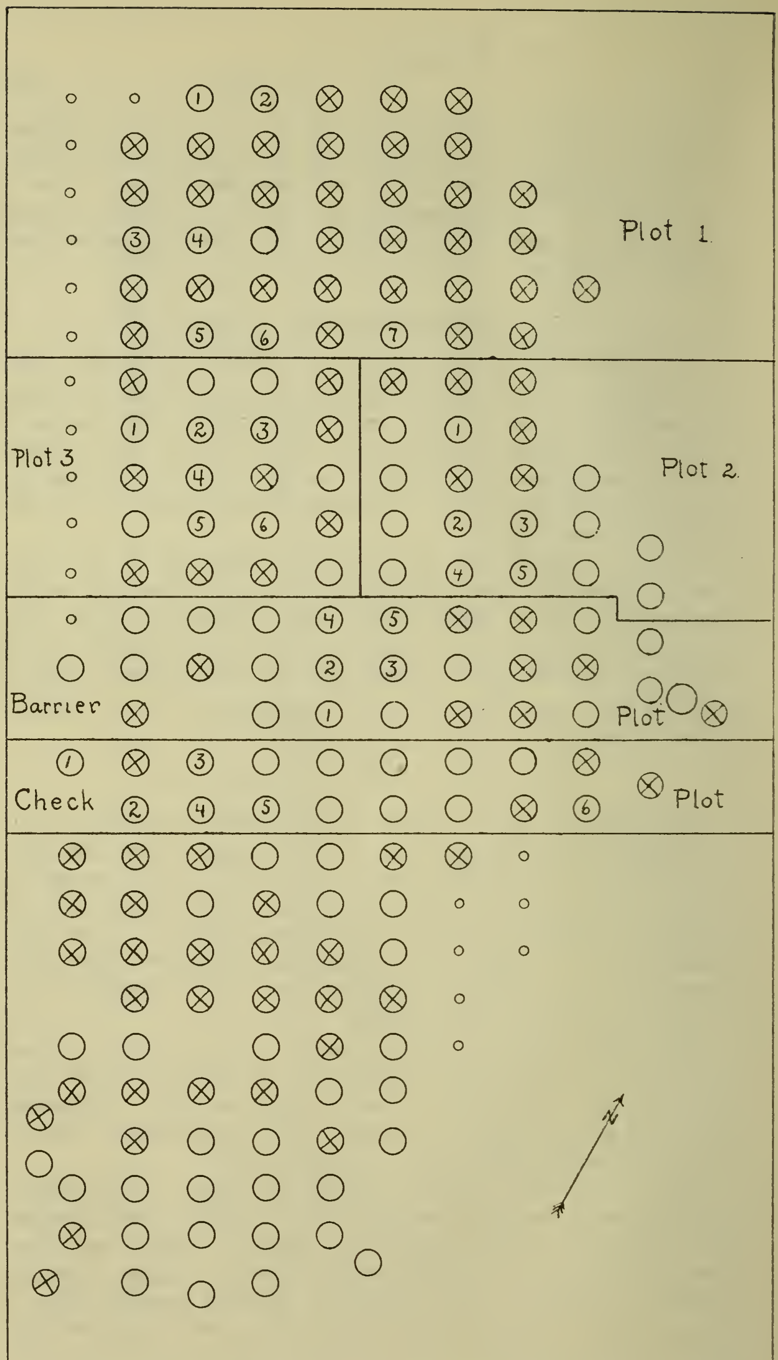


FIG. 30. Diagram of the orchard of Albert DeMeritt, Durham, N. H., 1908.

rel. Plot 4 was given the first, third, and fifth sprays with 2 lbs. arsenate of lead per barrel. It should be noted that the bearing trees in this orchard are quite scattering and that there were very few apples, which may account for the very peculiar results secured.

Orchard of W. A. Deering, Pittsfield, N. H.

This is the same orchard used in the experiments in 1907, but was arranged in plots as shown in Fig. 32. The first spraying was given May 30 and the third spraying June 24. At the time of the first spraying the blossoms had just fallen. An Eclipse barrel pump and quadruple Spramotor nozzles were used. Swift's arsenate of lead was used on all plots, 2 lbs. per barrel in every case.

Plot 1 was given the first spraying only, with about 75 lbs. pressure. Plot 1, row C, was sprayed with a nasal atomizer. Plot 2 was given spray 1 only, but with double Bordeaux nozzles, at 90 lbs. pressure, with the spray directed into the calyces and the trees thoroughly drenched. Plot 3 was given the third spraying only. Plot 3, trees 1-5 had the apples covered with paper bags before the spraying, which were removed immediately afterward in order to show the value of the spray placed on the surface of the apples. Plot 4 was given sprays 1 and 3. Plot B, barrier plot, was treated like Plot 4. Plot C formed the check plot and was unsprayed. The drops of about two weeks in September were not secured owing to the inroads of cattle, but the proportion of these to the total number of drops is so small as not to materially invalidate the records.

Analyses of Insecticides Used.

Through the courtesy of the Chemical Department many of the insecticides and fungicides used in the experiments were analyzed, with the following results:

INSECTICIDES.

Green Death. As_2O_3-49.5 per cent. CaO-32.1 per cent. Cr_2O_3-1 per cent. $CaCO_3$-35.2 per cent. Probably arsenite of lime. Very soluble.

Arsenates of Lead or Compounds.		Water. Per cent.	Lead Oxid. Per cent.	Arsenic Oxid. Per cent.	
Eagle Brand	1906.		37.4	8.5	
	1907.	39.	38.9	15.8	
Swift's	1906.		40.	14.	
	1907.	44.8	36.5	16.6	
Target Brand	1906.		39.5	13.9	
Diaparene	1906.		40.2	12.5	
	1907.	45.4	33.9	13.6	
Star	1907.	38.	43.2	14.1	
Pyrox			21.5	7.5	CuO 1.4 Per cent.
Acetate of Lead			60.3		
Arsenate of Soda				48.	

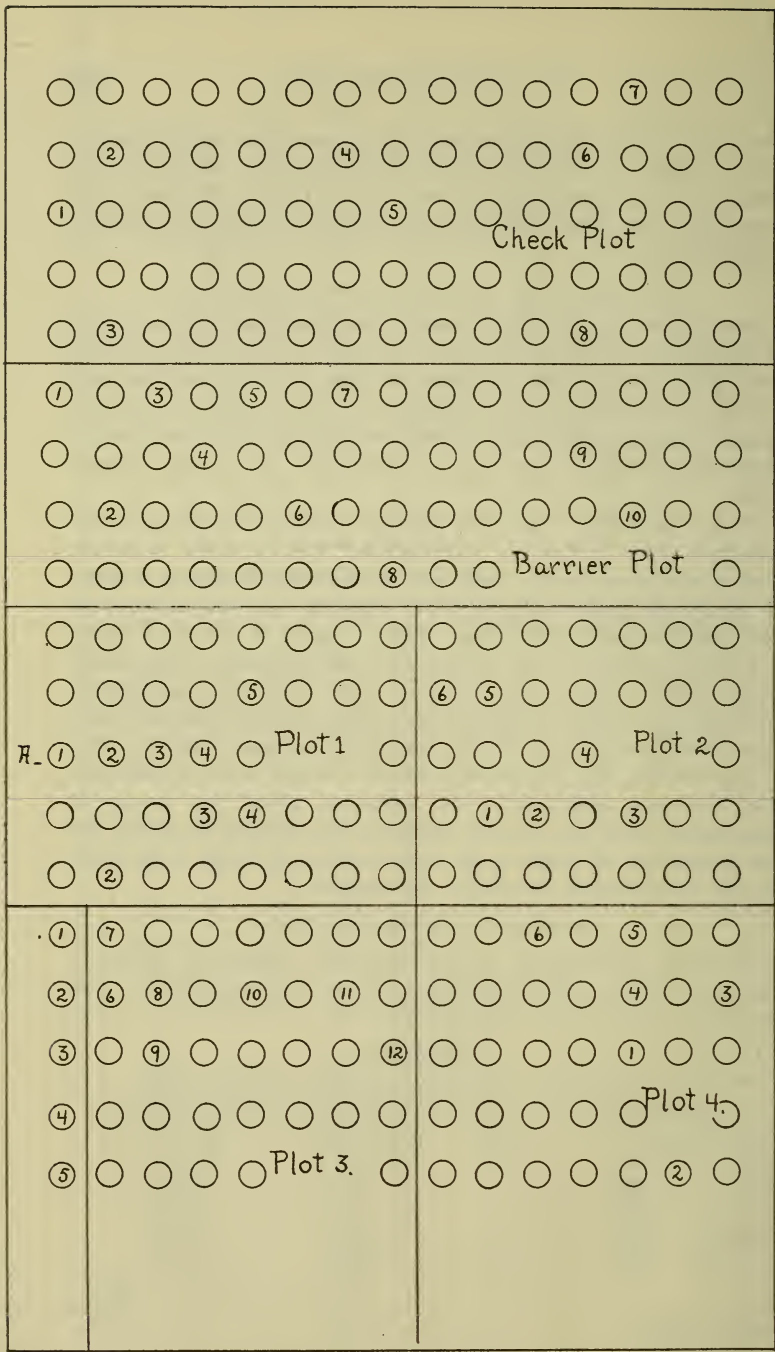


FIG. 32. Diagram of the orchard of W. A. Deering, Pittsfield, N. H., 1908

FUNGICIDES.

1906	CuO. Per cent.	As_2O_3 Per cent.	CaO. Per cent.	P_2O_5 Per cent.	Water Per cent.
Lenox Bordeaux Mixture (paste)	1.26	3.00	28.5		67
Bug and Blight Dust. No. 3	9.21	7.1	41.4		
Leggett's Dry Bordeaux	16.6 (as cupric oxid)		34.		
Copper Phosphate	20.3	2.5	17.5	16.2	

METHODS OF RECORDING AND TABULATING RESULTS.

The windfalls were gathered frequently during the season as often as necessary to secure them all, and commencing as soon as the fruit was the size of a good-sized marble. All the windfalls were carefully examined to determine whether the larva had entered the calyx or side of the fruit, most of the smaller fruits being sliced to make certain. In 1906 and 1907 all windfalls up to the date of the appearance of the second brood were counted as the work of the first brood, and the work of the second brood was then recorded separately for the remaining windfalls and picked fruit, the determination of the brood being based upon the character of the work and the size of the larva. This permitted some error, but it is believed that the possible per cent. of error was very slight. However, to distinguish certainly between the work of the first and second broods, in 1908 at the time when the second brood should be ovipositing and eggs hatching the trees were gone over by hand and all of the fruit injured by the first brood was picked off and recorded. This prevented a complete record of the "dropped" fruit, as most of these wormy fruits would have dropped later. After the records for the season were secured, the dropped and picked fruit for each tree was determined and the trees of each plot arranged in tables as given in Tables 8 to 14, which show the variability of the various trees in each plot and the average for the plot. At first the average of the percentages of the trees in a plot was taken as the average per cent., but it was soon found that this was inaccurate, as sufficient weight was not given the variable number of apples on the different trees, which cause widely fluctuating percentages, so the total number of apples for the plot was divided into the total number of apples under the various headings, and percentages thus secured which truly represent the average of the whole plot. A brief study of the variation of trees in any and all of these plots will show the utter uselessness of basing conclusions regarding spraying experiments against the codling moth upon one or two or even three trees. Five trees is a minimum number for such work and the average of ten would be much more satisfactory. In all

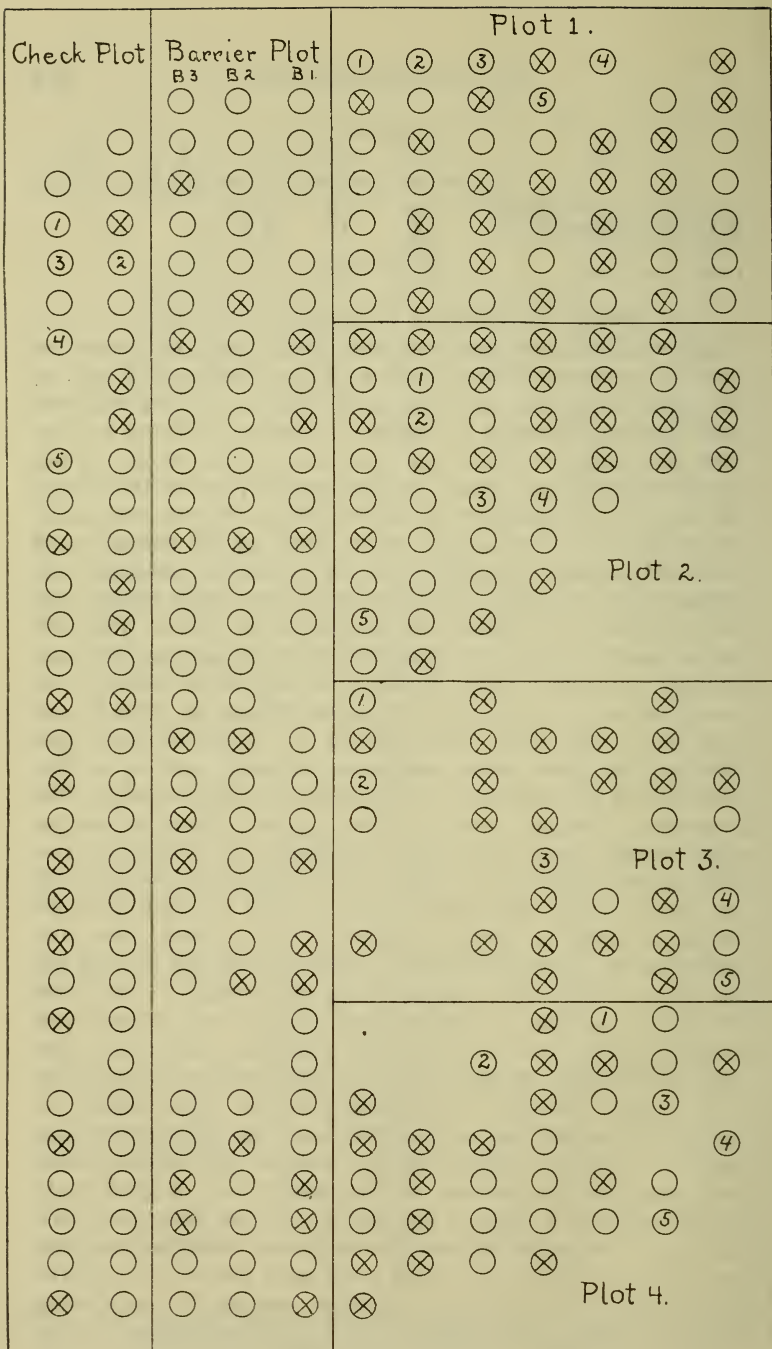


FIG. 31. Diagram of the Packers' Falls orchard, Durham, N. H., 1908.

of the records apples entered at the stem are counted as "side" wormy.

In an endeavor to determine how the various sprayings affect the larvae and where the larvae are killed by them, the data from all the plots was assembled in Tables 15, 16, 17. These tables separate the apples wormy by the first and second broods, and analyze both the work of each of the broods and the total for both broods, as regards the number injured by larvae entering the calyx and entering the side. A brief explanation of the various columns, their significance and how obtained, will be necessary. Column 1—"per cent. of total fruit," gives the percentage of the total fruit borne by the tree, which was injured by the first brood. Column 2 "per cent. of benefit," expresses this in terms of "benefit." In all cases in these tables the "benefit" is secured by subtracting the percentage in the previous column from that of the "check" plot and dividing the remainder by the percentage of the check, thus giving the amount gained, or benefit, in the plot under consideration over the untreated plot in terms of per cent., assuming that if the plot under consideration had 0 per cent. of the total fruit injured by the first brood that there would have been 100 per cent. benefit over the check. It is believed that such a method of expressing the "benefit," gives the most accurate measure of the effectiveness of the various sprays as regards any given point. Column 3 "per cent. of total wormy" gives the per cent. of the total number of wormy apples for the season which were injured by the first brood. In each case where the term "per cent. of total wormy" appears, it refers in like manner to the per cent. of the total wormy for the whole season which the apples wormy through the calyx or side of the first or second broods respectively form. Column 4, "benefit as 'total per cent. benefit'" gives the benefit shown in column 2 in terms of the "per cent. benefit" for the whole season. Thus, if the 'total per cent. benefit, for the whole season of Plot B in G. Woodman's orchard in 1908 (table 17) was 85 per cent., 62 per cent. of this was due to the spraying decreasing injury by the first brood and only 23 per cent. by decreasing injury by the second brood. In each column in which the term "benefit as 'total per cent. benefit'" appears, it refers in like manner to that part of the total benefit of the season secured in preventing injury by the First Brood, Total Calyx, or Side, or Second Brood, Total Calyx, or Side. Column 4 is secured by multiplying column 2 by column 3 of the check plot. Thus, column 4 gives the true index of

the value of the spray used on a given plot in comparison with the check and by dividing column 4 by the total benefit for the whole season, as given in the last column of the table, the part of the benefit due to the effect on the first brood can be secured in terms of percentage. Column 5 "per cent. of first Brood," gives the percentage of the apples injured by the first brood, which were entered at the calyx, and the next column the same in "per cent. benefit." The remaining columns under "Calyx" and "Side" are similar to those already explained. Under "Second Brood," the first four columns under "Total" are similar to the first four columns in the table under "First Brood." It is evident, however, that the apparent effect of any given treatment on the second brood cannot be due to its direct effect in killing the second brood of larvae, for in such plots the first brood of larvae have been killed out and there will be but few moths of the second brood to mature, and if none of the larvae of the second brood were killed we should find them decidedly fewer in the treated than in the check plots, owing to the effect of the spraying on the first brood. This will be particularly true where the plots are large and uniform and the second brood is small. If the "per cent. benefit" in "per cent. of total fruit" injured by the second brood is greater than the similar "per cent. benefit" in "per cent. of total fruit" injured by the first brood, then it is evident that the spray has given more benefit to the second brood than to the first brood, and the difference between them should give the direct effect on the second brood. Thus, by subtracting column 2 under First Brood from column 2 under Second Brood, we secure column 5 under Second Brood or "per cent. benefit, direct effect," and in the same manner are secured the direct effect upon the second brood *Calyx* and *Side* in contrast to the first brood. This may be seen in Table 15, line 2, where 16 per cent. is the direct effect on trees 11-15 in terms of the "per cent. benefit of per cent. of total fruit." In this particular case the first brood showed a benefit in column 2 of 20 per cent. If the second brood had showed a benefit in column 2 of only 20 per cent., no direct effect on the second brood could be attributed to the spray. Any per cent. of benefit above 20 per cent., in this case 16 per cent.. will therefore be due to the direct action of the treatment on the second brood. It is evident that if the treatment were entirely successful there would have been in this case 80 per cent. direct effect benefit on the second brood. In fact, only 16 per cent. was secured or 20 per cent. of the possible benefit due to direct

effect, which explains column 6 under "second brood," named under Direct Effect, "per cent. of possible benefit." Column 7 expresses the direct effect in terms of the "total benefit" for the season, and is secured by multiplying column 6 by column 3 of the check plot. The same explanation applies to the similar headings under "calyx" and "side," under Second Brood. In many cases no direct effect, whatever, is shown under the second brood, and it must be admitted that this method of ascertaining the direct effect on the second brood is rather complicated and not entirely satisfactory, but it seems to be mathematically correct, and the writer has been unable to devise any other means for expressing the matter. The following formulae may therefore be given:

(1) Per cent. Benefit, Direct Effect, Second Brood,=Per cent. Benefit per cent. of Total Fruit, 2d Brood, minus Per cent. Benefit, per cent. of Total Fruit, 1st Brood.

(2) Per cent. of possible per cent. benefit, direct effect, second brood,=(Per cent. benefit, per cent. of total fruit 2d brood, minus Per cent. benefit, per cent. of total fruit, first brood) divided by (100 minus per cent. benefit, per cent. total fruit, first brood.)

(3) Direct Effect Benefit in Total per cent. = Per cent. Direct Benefit 2d Brood X per cent. of total wormy check plot (2d brood.)

If we then wish to secure the amount of benefit due to the effect of the treatment through the first brood, both in destroying the first brood and also in thus preventing the increase of the second brood, exclusive of the direct effect of the treatment on the second brood, we must substract the "Direct benefit as per cent. of total benefit" (column 9, second brood) from the "Total per cent. benefit" (last column), giving the "total per cent. benefit" due to action of the treatment on and through the first brood. If this be divided by the "total per cent. benefit" we secure the percentage of the total benefit which may be attributed to the effect of the treatment on and through the first brood, as given in column 12, under first brood, Table 16, expressed by the following:

$$\text{Per cent. of Total benefit per cent., due to control of 1st brood} = \frac{\text{Total per cent. benefit}}{\text{Total per cent. benefit} - \text{Direct Benefit 2d brood in Total per cent.}}$$

Although these formulae and methods appear theoretically correct, it seems hardly possible that there was no direct effect upon the second brood by applying 10 lbs. of arsenate of lead at the third spraying as indicated in Table 17, next to last line, and that there was practically no direct effect on the second

brood in any of the plots in 1908. The further the matter is studied the more evident it becomes that the codling moth does not yield gracefully to being the subject of mathematical calculations.

Comparison of Insecticides.

In the orchard of H. H. Thompson at Walpole in 1906 the Greenings sprayed with 1 lb. arsenate of lead showed 49 per cent. benefit for the whole season, while those sprayed with 1-4 lb. Paris green showed 53 per cent. and 45 per cent. benefit, the insecticide being used with Bordeaux mixture in both cases. In DeMeritt's orchard in 1907 (see table 15), 1-3 lb. of Paris green per barrel of Bordeaux on trees 21 to 35 gave a benefit for the season of 44 per cent., while trees 41 to 45, sprayed with 2 lbs. arsenate of lead showed a benefit of 43 per cent. In the orchard of W. A. Deering, in 1907 (see table 16), plots 4 and 5, and 6 and 7, sprayed with 1-3 lb. Paris green per barrel of Bordeaux, showed a benefit for the season of 86 per cent. and 91 per cent. respectively, which benefit equals that of the plots sprayed in like manner with 2 lbs. arsenate of lead per barrel. These figures would tend to confirm the observations of other workers, that arsenate of lead has no advantage over Paris green for the codling moth when both are used with Bordeaux mixture. Where used without the Bordeaux mixture, there can be no doubt that the adhesive properties of the arsenate of lead would make it much superior to Paris green, though we have no experiments to demonstrate the fact. Trees 36 to 40 in the DeMeritt orchard in 1907 were sprayed with 2-3 lb. Paris green per barrel, against 1-3 lb. per barrel on trees 31 to 35, but showed only 4 per cent. more benefit for the whole season, showing that 1-3 pound per barrel is, probably, strong enough if properly applied.

As regards the amount of arsenate of lead to be used it is quite evident that two pounds per barrel are much superior to one pound. In the DeMeritt orchard in 1906 (see table 15) trees 51 to 55 received but one pound per barrel and showed but 11 per cent. benefit for the season, while trees 41 to 45 were given 2 lbs. per barrel and showed 43 per cent. benefit for the season. In the other orchards sprayed in 1906 with one pound of arsenate of lead per barrel, an average benefit of 66 per cent. was secured with the first two sprayings, but in 1907 and 1908 by the use of 2 pounds per barrel an average benefit of from 85 per cent. to 90 per cent. was secured with the same sprayings under

diverse conditions. Two pounds of arsenate of lead per barrel are practically the equivalent of 1-3 pound of Paris green in effectiveness, although containing slightly more arsenic.

The addition of soap has been frequently recommended as securing greater adhesiveness for the spray, and in spreading it more evenly on the foliage. In the Woodman orchard in 1907 (table 16) trees 437 and 438 had three pounds of Good's resin fish-oil soap added to each barrel of mixture, while the adjacent trees of plot 4 were sprayed the same way without the soap. The trees sprayed with the soap gave a benefit of 87 per cent. for the whole season, but very slightly more than those on which no soap was used. Also, in the Deering orchard in 1907 (table 18) plot 15 was given the fifth spraying for the second brood with the addition of three pounds of the resin soap, while plot 14 was sprayed in the same way without the soap, and the latter plot showed the greater benefit.

It has frequently been asserted that arsenate of lead is not as effective when used with Bordeaux mixture. A comparison of plots 3 and B in the Deering orchard in 1907 (table 16) with plot 13, the former having Bordeaux added, shows practically no difference in the benefit for the season. Nor do the benefits secured in 1907 on the orchards in which Bordeaux was used with the arsenate of lead differ materially from those secured that year and in 1908 on trees where only arsenate of lead was used.

The Time to Spray and How the Spray Effects the Larva.

Terminology. In speaking of the various sprayings, the first spraying, I, is that given just after the petals of the flowers drop. The second spraying, II, is that applied a week or ten days later. The third spraying, III, is applied when the eggs of the first brood are deposited and is usually three or four weeks after the petals drop. The fourth spraying was used for fungicide applications only and is not referred to in this discussion. The fifth spraying, V, is applied at the time of emergence of moths of the second brood or the first appearance of second brood larvae, and will usually be about the first week of August.

The First Spraying. I.

It has been generally conceded that the spraying just after the blossoms fall is the most important in fighting the codling moth, from the fact that as shown above, page 412, 65

per cent. of the first brood of larvae enter the apples through the calyxes. The object of the first spraying has, therefore, been to deposit the poison in the calyx cavity. Recently great emphasis has been placed by western entomologists upon the entire efficacy of one spraying if the lower calyx cavity be filled with poison by means of a hard driving spray, which will be further discussed below. It is a fact, however, that all investigators have shown that this first spray also materially reduces the number of larvae entering the sides of the apples, which could not be due to the poison in the calyx. Evidently those killed by the first spray which would otherwise have entered the side, must have been destroyed on the foliage or by eating into the surface of the sprayed apple. To determine the influence of the spray on the foliage as compared with that placed in the calyx by the first spraying several trees were sprayed by hand with a nasal atomizer so that the spray was deposited in the calyx of each apple, but practically none was placed on the foliage. Four trees, 442 to 445, were thus treated in the Woodman orchard in 1907; three trees in the same orchard, plot 2, in 1908; and four trees in the Deering orchard in 1908 (see tables 16, 17). The plots on which the atomizer was used gave a benefit for the whole season of 62 per cent., 78 per cent., and 84 per cent., respectively, averaging 75 per cent. Eight plots given the first spraying in the ordinary way so that the foliage was covered, averaged 82 per cent. benefit for the whole season. Analyzing this benefit as the effect on the first and second broods, and on those entering the calyx or side, we find that the trees treated with atomizers gave 21 per cent. benefit in "Total per cent. benefit" as regards the calyx, 25.8 per cent. as regards the side wormy, and 27.9 per cent. as regards the injury by the second brood. The eight plots given spray I in the usual way, gave 23.4 per cent. for the first brood—calyx, 27.3 per cent. first brood side, and 31 per cent. for the second brood, showing that the effect of both treatments must have been much the same on the larvae. This would seem to indicate that the spray on the foliage is of no value, but further experiments will show the contrary to be true. The benefit from this spraying is practically the same on those larvae entering the calyx or side of the apple, when applied either with the atomizer or by the ordinary manner. How the spray placed in the calyxes with an atomizer can destroy larvae which normally enter the sides of the apples and which therefore do not feed in the calyx, is a mystery which we have been unable to

solve, but the facts are very clearly shown by the figures of all three plots sprayed with the atomizer. The only possibility is that the larvae entering the sides of the apples are killed by eating the poisoned surface of the apple which would be poisoned even when the spraying was done with an atomizer, and the effect of placing bags over the apples before giving the third spraying, as described below, lends support to this explanation.

The time of the first spraying is a matter of vital importance. It has long been recommended that the spraying must be done before the calyx lobes close. Observation shows that in New Hampshire the calyces of the Baldwin apples (practically 90 per cent. of the apples marketted are Baldwins, and all references in this paper are to Baldwins unless, otherwise specified), close about a week after the last petals have dropped. It is safe to commence spraying after two-thirds of the petals have dropped, for the first flowers to drop are those which usually set as fruit, and by the time two-thirds of the petals have dropped. practically all flowers have been pollinated and there is no danger of injury to the flowers or to bees. The lack of effect of the spraying in the Hooper orchard at Walpole in 1906 (table 18), very clearly shows the necessity for spraying before the calyces close. We had expected to spray this orchard at the same time as that of Mr. Thompson, but the Hooper orchard was on a south slope and fully a week ahead of the Thompson orchard in maturity of blossoms. Practically no benefit whatever was shown by the spraying in the Hooper orchard, while an average of 50 per cent. benefit for the season was secured in the Thompson orchard. Had the Hooper orchard been sprayed with arsenate of lead a benefit would possibly have been secured from the effect of killing larvae outside of the calyx, as heavy rains occurred after the spraying and probably washed much of the Paris green off.

Drenching vs. Mist Sprays. As mentioned above it has been recently recommended that the first spraying be given with a high pressure and coarse, driving spray, so that it will be driven between the pillars of the stamens down into the lower calyx cavity, in which cavity it is claimed that the most of the eating by the young larva is done before tunnelling into the core. Remarkable results are claimed for such spraying, in contrast to the old method, in which the finest mist was thought the most desirable and economical. Assuming the correctness of the results secured in the West, though some of the records do not

bear close analysis, and feeling that the same methods might be equally efficient in New England, we arranged to contrast two plots given only the first spray, one in the ordinary manner with a fine mist, and the other with as high a pressure as possible, thoroughly drenching the tree with a coarse spray from Bordeaux nozzles. Such comparisons were made in two orchards in 1907 and in three orchards in 1908. In the two in 1907 and one in 1908 the drenching spray was given with a barrel pump which could not be kept at over 80 to 100 lbs. pressure. But on two of the 1908 plots the drenching was done with a gas sprayer giving 110 to 120 lbs. pressure, with no material difference in the results. If we compare the average Benefit in "Total

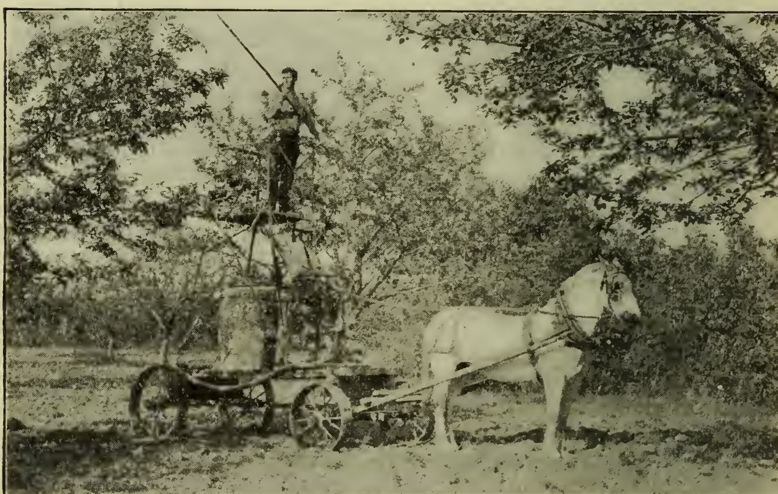


FIG. 33. Niagara gas sprayer outfit used in experiments at Durham.

Per Cent. Benefit" for the first brood for the plots sprayed with the mist or drenching spray, we find that both average 51 per cent. benefit. In some plots a decided advantage seems to be shown for the drenching spray, especially plot 1 of the Packers Falls orchard in 1908 (table 17) where the drenching gave 78 per cent. benefit for the season, while the mist gave only 60 per cent., and also in the other two orchards in 1908, in which the drenching gave 96 per cent and 80 per cent. in comparison with 92 per cent. and 73 per cent., respectively. But if the effect of this driving spray directed into the calyces, is to deposit the poison in the lower calyx cavity, a marked benefit should be

shown in the per cent. injured through the calyx. If we compare the different plots as regards "per cent. benefit, per cent. of first brood, injury through the calyx," (column 6, table 17), which should show the relative proportion entering the calyx or side as influenced by the different treatment, we find the figures absolutely contradictory. If we compare those entering the calyx in terms of "per cent. benefit, per cent. of total fruit," (column 8), we find a slight advantage for the drenched plots. But if we compare the benefit to the calyx in terms of "Total per cent. benefit," (column 10), there is practically no difference in favor of one treatment over the other. On the other hand, if we study this table further we find that in the case of plot I of the Packers Falls orchard in 1908 that the advantage of the drenching over the mist spray was clearly due to its effect on the second brood (see column 4 under second brood, table 17). It is entirely evident from the large amount of data from these five plots that the drenching spray has no particular advantage over the mist spray, except as it may deposit more material on the foliage and apple. The reason for this is readily found by a little study of the Baldwin apple. Dr. Ball* has given us a figure which shows an apple with the calyx lobes still open "two weeks after blossoming," and with the stamen bars shrivelled sufficiently to allow the passage of spray between them to the lower calyx cavity. There can be no disputing the desirability of spraying so as to deposit a spray in the lower calyx cavity, where it is so possible, but a comparison of the structure of the Baldwin apple as it grows in New Hampshire, shows it to be entirely impossible, as the experiments cited corroborate. As mentioned above, the sepals usually close about one week or at most ten days after the blossoms drop. At this time the stamens are still entirely turgid and no spray can be forced between them, no matter how high the power or coarse the spray. If apples be examined a week or ten days after the sepals have entirely closed, the stamens will still be found turgid, as we have found by the examination of numerous specimens the present year. Unfortunately, we secured no photographs of this condition, but Prof. M. V. Slingerland has made the same observations independently† and has kindly permitted the reproduction of his photographs, Plate 20, which shows this structure very clearly. Such being the case, the question of a drenching, driving spray as compared with a mist spray, becomes one of cli-

* Bulletin Bureau of Entomology, No. 67, pg. 71, fig. 4.

† Journal of Economic Entomology, No. 6, Dec., 1908

mate and varieties, and which method will be most efficacious in any region cannot be dogmatically asserted until the method of growth of the apples in that region has been studied. There can be no question, however, that thorough spraying must be insisted upon. The old rule, spray until the tree commences to drip and then stop, still seems a safe one, and to spray until there are puddles under the tree is merely a waste of labor and material under New England conditions.

The Second Spraying. II.

Until the last year or two it has been customary to recommend that the second spraying for the codling moth be made a week or ten days, or even two weeks, after the first spraying. Inasmuch as the calyces have closed at that time it is evident that such spraying can only be effective in the degree which it covers the foliage and apples. As the young larvae do not hatch for nearly a month after the first spraying, it is also evident that the second spraying, applied ten days after the first, might be more or less washed off by heavy rains before the young larvae had hatched and could be affected by it. We were led to question, therefore, whether the second spraying, so-called, was being applied at the right time. The results upon this matter are fairly uniform and conclusive. In the DeMeritt orchard in 1906 trees 11—16 received spray I, while trees 50—55 received I and II. As the latter plot was next to the check plot, with no barrier plot, it is evident that the moths of the second brood would have been more numerous upon it, and that the total benefit for the season, or, for the second brood, would not be reliable, as the figures show. But there should be a fair comparison of the effect of the addition of spray II to spray I as regards the effect on the first brood. Although sprays I and II gave slightly more benefit as regards calyx wormy by first brood, there was decidedly less benefit as regards those side wormy, and the total effect on the first brood was less than with spray I alone. Trees 46—50 were given the first and third sprayings in the same manner. Comparing the effect on the first brood we find that sprays I and III gave 15.9 per cent. benefit as "total per cent. benefit per cent." while sprays I and II gave only 5.5 per cent. Again comparing trees 26—30 with 21—25, the first of which were given sprays I and II with KLBP, and the second lot sprays I and III, it is found that the latter group had 49 per cent. benefit for the season against 41 per cent. for sprays I

THE CLOSING OF THE APPLE CALYX.

A, A, and B, sections of apples at different stages in the closing of the calyx showing the stamens. C,—a later stage showing the closing of the calyx, but the stamen pillars still turgid. D,—young codling moth larva feeing in upper calyx cavity. (After Slingerland.)

and II, due to the greater benefit of the third spray on the second brood.

In Gilman Woodman's orchard in 1907 plot 5 was given spray II only and plot 6 spray III only. The former gave 25 per cent. benefit for the season and the latter 47 per cent., while other plots given only spray III, averaged 83 per cent. benefit.

In DeMeritt's orchard in 1908 plot 2 was given spray II only and plot 3 spray III only. The former gave 73 per cent. benefit for the season and the latter only 66 per cent., showing an advantage for spray II. This may be explained by the fact that there was practically no rain during the whole summer after either of these sprays, and that the season was an early one, so that the difference of ten days or two weeks in the time of application would make no difference. In the Smith orchard at Deerfield in 1907, plot 16 was given spray I and plot 14 sprays I and II, but the latter showed only 61 per cent. benefit for the season and the former 66 per cent. These figures do not prove that spray II is of no value, but do show that it is of less value than spray III, and in many cases of little, if any additional value when sprays I and III are given. The latter may be seen by comparing plot 3 of the Woodman orchard in 1907, which was given sprays I and II, with plot B which was given sprays I, II, and III, the latter showing 96 per cent. benefit for the season and the former 93 per cent., the larger benefit amounting to but 3 per cent., due to the second spraying being largely due to the increased effect on the second brood, due to the greater amount of poison on the foliage.

The Third Spraying. III.

The reason for spray III, namely, that a spray should be applied as the young larvae are hatching, has already been intimated and its superiority to spray II has been shown. From the studies of the feeding habits of the young larvae, it must be evident that any poison deposited upon the foliage must kill many of them when feeding upon it before they seek the apples. Five plots have been sprayed with the third spraying only and have shown an average benefit of 70 per cent. for the whole season, against an average of 82 per cent. secured with spray I alone. An analysis of the influence of spray III shows that of the total benefit 33 per cent. is due to the effect on the second brood, 18 per cent. on the calyx wormy and 19 per cent. on the side wormy, first brood. It is interesting to note that the average effect of spray I and spray III

on the second brood is 31.3 per cent. and 32.6 per cent., respectively, showing practically no difference.

If the effect of spray III be due to the poison on the foliage only, then if the apples were covered and the foliage of the tree then sprayed there should be as much benefit as if the apples had been sprayed also. But if there is less benefit with the apples covered it is evident that the difference in the benefit must represent the value of the spray deposited on the apples. Such an experiment was made twice. In 1907 one tree in the Woodman orchard, table 16, tree 448, was given spray III, after all of

FIG. 34. Tree 448 of the Woodman orchard, Durham, N. H., 1907, with the apples bagged during spray III.

the apples had been covered with paper bags, which were removed immediately after the spraying. Care was taken to cover only the stems and not the nearby foliage. It was intended to treat several trees thus but the vast amount of labor involved in bagging all the apples (3924) on even one large tree prevented a larger experiment. In 1908 four trees in the Deering orchard, table 17, Plot 3A, were similarly bagged. These were smaller trees with a light crop of fruit, totalling only 668 for the four trees. It is evident, therefore, that the one large tree was fully

as fair a test as the four small ones. The one tree gave a benefit for the season of 52 per cent., while the four in 1908 showed only 24 per cent. benefit, the two averaging 38 per cent., of which 9 per cent. is the effect on the first brood and 29 per cent. on the second brood. In 1907 the effect was practically all on the second brood, 46.8 out of 52 per cent., while in 1908 12 per cent. of the effect was upon the first brood and 11.6 per cent. on the second brood, or about the same proportion as occurs with spray III when the apples are exposed. It seems more probable the latter condition would be the normal effect of such spraying the foliage only as regards influence on the proportion of first brood and second brood larvae. Thus, about 50 per cent. of the effect of spray III on the first brood larvae, and 58 per cent. of the effect on the second brood, must be due to the spray on the foliage, and the balance must be due to the spray deposited on the apples. It should be pointed out that spray III may effectually reduce the number of larvae entering the calyx though no spray be deposited in the calyx for we, and others, have observed that very often the larvae eat their way through one of the sepals, rather than going to the apex and entering between them.

From the above data we would naturally infer that the best results would be secured by combining sprays I and III, and such has been our advice and that of several other investigators for the past two years. Our evidence as to the value of giving spray III in addition to spray I, is not entirely satisfactory, but is as follows: In 1906 in the DeMeritt orchard, trees 11—15, given only spray I, showed but 14 per cent. benefit for the season, while trees 46—50, given sprays I and III, showed 31 per cent. benefit, this being due to the superior effect of the addition of spray III on the first brood. In the Woodman orchard in 1907, plots given spray I only gave 91 and 89 per cent. benefit for the season, while one plot given sprays I and III, showed only 93 per cent. benefit for the season. In the Woodman orchard in 1908, plot B (barrier plot), sprayed with I and III, showed no more benefit as regards the first brood than plots 1 and 3 given only spray I, and showed less benefit for the whole season, probably due to the inroads from the neighboring check plot of the second brood of moths. In the Packer's Falls orchard in 1908 the plot given I and III, though 10 lbs. arsenate of lead per barrel were used at the third spraying, showed less benefit than the plots given only spray I. This is doubtless due to the small number of fruits and the scattered nature of the

bearing trees, making fair comparison impossible. In the Deering orchard in 1908, two plots having only spray I, showed 73 per cent. and 80 per cent. benefit for the season, while two plots which had spray I and III, showed 87 and 78 per cent., or an average of 82.5 per cent. against 76.5 per cent., or a gain of 6 per cent. Two plots in the DeMeritt orchard were given sprays I and III in 1908, and showed 80 and 89 per cent. benefit for the season or an average of 84.5 per cent. This orchard had about the same amount of worminess on unsprayed trees as the Deering orchard. It should be remembered that 1908 was a dry season and there was practically no rain to wash off the first spraying, so that the third would not be of as much value as in 1906, when there were heavy rains. As regards the value of spray III, the only conclusion possible is, that if no rains occur after spray I, that the application of spray III will be of doubtful value when unsprayed trees show not over 50 per cent, worminess for the season. If for any reason spray I cannot be given, or if spray I is followed by rains, a spraying should be given about three to four weeks after the blossoms fall (spray III) by all means.

How the larvae are killed. If we attempt to determine just how the larvae are killed by the first spraying we find that the statistics in tables 16, 17 and 18 are full of inexplicable inconsistencies and contradictions. They represent, however, probably as careful and extensive attempts to determine these matters as have ever been made. The benefit shown by spray III and the fact that it is due both to the spray on the foliage and on the apples, in almost equal proportion, would seem to indicate that the effect of spray I, as far as it is deposited outside of the calyx is much the same. But when we attempt to push the analysis of the figures further by means of comparisons which it would seem should throw light on the matter, we meet with failure. The general facts seem quite evident, however, that if the foliage as well as the calyces be thoroly sprayed, that there is almost an equal chance that the larva may be killed by eating the foliage or surface of the apple, or by feeding in the calyx, and we would venture the opinion, which we would not attempt to prove by the statistics, though it is based upon them, that in New Hampshire on the Baldwin apple, about half of the larvae are killed in the calyx and about half by feeding on the foliage or surface of the apple.

The Fifth Spraying, V.

The fifth spraying is designed to cover the foliage and apples with poison so as to destroy the young larvae of the second brood, and is therefore applied when the moths of the second brood commence to appear early in August.

Plot A of the Woodman orchard was given sprays I, III and V in 1907, but showed no greater benefit than plot 3 with only sprays I and III. Plots 14 and 15 of the Deering orchard were given only spray V in 1907 and showed 52 per cent. benefit, but of this 32 per cent. was due to benefit to the first brood and 20 per cent. to the second brood. It is impossible to see how the fifth spraying could benefit the first brood, yet there seems to be no other explanation of the records, and it is evident that spray V alone gave considerable benefit. It should be stated, however, that these two plots were mostly Ben Davis, while the check plots were McIntosh Red and Baldwin, which may be a disturbing factor in the comparison. As a general rule, however, Ben Davis is more affected by the Codling moth than most varieties. Plot 4 of Packers Falls orchard (Table 17) was given sprays I, III and V in 1908, and showed 72 per cent. benefit. Plot 3, which was given spray I with the same amount of arsenate of lead (2 lbs. per barrel), and spray III with 10 lbs. per barrel, showed 75 per cent. benefit. The two plots gave practically the same benefit from injury by the first brood, but plot 3 gave slightly more benefit for second brood injury.

This would indicate that a larger amount of lead at the third spraying would be as effective as adding the fifth spraying, but as 1908 was a dry season, this might not always prove true.

Altho our experimental evidence as to the value of spraying for the second brood is thus largely negative and rather unsatisfactory from many standpoints, yet further experiments were not thought advisable in view of the excellent results secured from sprays I and III, these proving so effective that with but a small second brood another spraying could hardly prove profitable even if somewhat beneficial.

Effect of Spraying on the Amount and Worminess of Dropped and Picked Fruit.

The effect of the different sprayings upon injury by the first and second broods is a matter of interest to the entomologist and of importance in forming a basis for his recommendations, but the orchard owner is chiefly interested in the effect of the spraying on the amount of picked fruit free from worms.

TABLE 8. *Injury by Codling Moth in Orchard of Arthur Ladd, Deerfield, N. H., in 1907.*
Plot C. No treatment.

			FIRST BROOD.				SECOND BROOD.				TOTAL.			
Tree.		Total Apples.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
C1	D.*	559	51		24		46		41		97		65	
	T.†	688	51	**49**	24	**47**	53	**51**	44	**83**	104	**15.1**	68	**65**
C2	D.	539	73		27		34		23		107		50	
	T.	692	77	**63**	28	**36.3**	45	**37**	29	**64.4**	122	**15.3**	57	**46**
C3	D.	364	55		20		24		19		79		39	
	T.	527	65	**63**	23	**35.3**	38	**37**	27	**71**	103	**19.5**	50	**48.5**
C4	D.	234	35		14		12		9		47		23	
	T.	297	39	**76**	15	**38.4**	12	**24**	9	**75**	51	**17.1**	24	**47**
C5	D.	365	99		36		17		13		116		49	
	T.	448	103	**84**	37	**35.9**	20	**16**	16	**80**	123	**27.4**	53	**43**
C6	D.	352	50		13		15		13		65		26	
	T.	483	58	**72.5**	20	**34.4**	22	**27.5**	16	**72.7**	80	**16.5**	36	**45**
C7	D.	135	37		12		3		2		40		14	
	T.	181	40	**87**	13	**32.5**	6	**13**	5	**83.3**	46	**25.4**	18	**39**
C8	D.	186	44		17		11		10		55		27	
	T.	214	46	**79**	17	**36.9**	12	**21**	11	**91.6**	58	**27.1**	28	**48**
Total	D.	2734	444		163		162		130		606		293	
	T.	3530	479	**70**	177	**34.9**	208	**30**	157	**75.4**	687	**19.4**	334	**48**

Plot A. Treatment. Spray I, II. 2 lbs. arsenate of lead and Target Quick Bordeaux.

A1	D.	396	26		15		6		4		32		19	
	T.	1462	27	**67.5**	15	**55.5**	13	**32.5**	11	**84.6**	40	**2.7**	26	**65**
A2	D.	926	49		35		15		13		64		48	
	T.	2126	57	**68**	42	**73.6**	27	**32**	25	**92.6**	84	**3.9**	67	**80**
A3	D.	805	24		16		17		15		41		31	
	T.	1909	29	**55.7**	16	**55.1**	23	**44.3**	21	**91.3**	52	**2.7**	37	**71**
A4	D.	134	12		7		0		0		12		7	
	T.	335	16	**100**	7	**43.7**	0	**0**	0	**0**	16	**4.7**	7	**43**
A5.	D.	174	14		4		7		6		21		10	
	T.	690	17	**65**	4	**23.5**	9	**35**	8	**88.8**	26	**3.7**	12	**46**
Total	D.	2435	125		77		45		38		170		115	
	T.	6522	146	**67**	84	**57.5**	72	**33**	65	**90.2**	218	**3.3**	149	**67**

D.*—Drops.

T.†—Total for season; drops and picked.

TABLE 8.—*Continued.*

Plot B. Treatment, Spray I, II. 2 lbs. arsenate of lead and Leggett's Dry Bordeaux, 10 lbs. per barrel.

			FIRST BROOD				SECOND BROOD				TOTAL			
Tree.		Total Apples	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
B22	D.	1124	19		15		5		5		24		20	
	T.	1983	24	**80**	17	**70.8**	6	**20**	6	**100**	30	**1.5**	23	**76**
B23	D.	537	24		17		7		6		31		23	
	T.	1269	25	**73.5**	17	**68**	9	**26.5**	7	**77.7**	34	**2.6**	24	**70**
B24	D.	281	13		7		3		3		20		10	
	T.	1381	13	**32.5**	7	**35.8**	27	**67.3**	25	**74**	40	**2.1**	32	**80**
B25	D.	579	15		10		12		11		27		21	
	T.	1124	20	**51.3**	10	**50**	19	**48.7**	18	**91.7**	39	**3.4**	28	**71**
Total	D.	2521	71		49		27		25		98		74	
	T.	5757	82	**57.3**	51	**62.1**	61	**42.7**	51	**83.6**	143	**2.4**	102	**71**
Plot C. Treatment, Spray I, II. 2 lbs. arsenate of lead and one gallon Lion Bordeaux per barrel.														
C36	D.	278	19		7		8		5		27		12	
	T.	733	21	**70**	7	**33.3**	9	**30**	6	**66.6**	30	**4**	13	**43**
C37	D.	317	28		16		4		4		32		20	
	T.	957	33	**67.3**	16	**48.4**	16	**32.7**	16	**100**	49	**5.1**	32	**65**
C38	D.	106	13		6		7		4		20		10	
	T.	440	13	**65**	6	**46.1**	7	**35**	4	**57.1**	20	**4.5**	10	**50**
C39	D.	2	0		0		0		0		0		0	
	T.	138	0	**0**	0	**0**	0	**0**	0	**0**	**0**	**0**	**0**	**0**
C40	D.	198	15		9		4		3		19		12	
	T.	509	15	**65.2**	9	**60**	8	**34.8**	6	**47**	23	**4.5**	15	**65**
Total	D.	901	75		38		23		16		98		54	
	T.	2777	82	**67.2**	38	**46.3**	40	**32.8**	32	**80**	122	**4.4**	70	**57**

Plot D. Treatment, Spray I, II. 2 lbs, arsenate of lead and 3:4 Bordeaux per barrel.

D51	D.	180	6		2		0		0		6		2	
	T.	720	8	**72.7**	2	**25**	3	**27.3**	3	**100**	11	**1.5**	5	**45**
D52	D.	24	3		2		0		0		3		2	
	T.	295	8	**80**	2	**25**	2	**20**	2	**100**	10	**5.3**	4	**40**
D53	D.	6	1		1		0		0		1		1	
	T.	389	7	**58.3**	1	**14.2**	5	**41.7**	5	**100**	12	**3**	6	**50**
D54	D.	258	16		12		1		0		17		12	
	T.	937	25	**83.3**	12	**48**	5	**16.7**	4	**80**	30	**3.2**	16	**53**
D55	D.	126	11		9		0		0		11		9	
	T.	925	14	**63.6**	9	**62.2**	8	**36.4**	8	**100**	22	**2.3**	17	**77**
Total	D.	594	37		26		1		0		38		26	
	T.	3266	62	**73**	26	**41.9**	23	**27**	22	**95.6**	85	**2.6**	48	**57**

Plot E. Treatment, 5 lbs. Pyrox per barrel. Spray I, II.

E56	D.	1315	26		15		24		21		50		36	
	T.	3114	30	**38.4**	18	**60**	48	**61.6.**	44	**91.6**	78	**2.5**	62	**80**
E57	D.	795	14		8		28		22		42		30	
	T.	2113	21	**33.8**	15	**71.4**	41	**66.2**	35	**85.3**	62	**2.4**	50	**80**
E58	D.	1005	29		21		11		10		40		31	
	T.	2603	31	**53.4**	2[illegible]	**70.9**	27	**46.6**	26	**96.2**	58	**2.2**	48	**82**
E59	D.	463	14		12		13		10		27		22	
	T.	1404	20	**55.5**	17	**85**	16	**44.5**	13	**81.2**	36	**2.5**	30	**83**
E60	D	328	15		11		3		3		18		14	
	T.	1159	21	**63.6**	15	**71.4**	12	**56.4**	12	**100**	33	**2.8**	27	**81**
E61	D.	495	23		15		10		9		33		24	
	T.	1557	36	**69.2**	22	**61.1**	16	**30.8**	14	**87.5**	52	**3.3**	36	**69**
Total	D.	4401	121		82		89		75		210		157	
	T.	11950	159	**49.8**	109	**68.5**	160	**50.2**	144	**90**	319	**2.6**	253	**79**

TABLE 8.—*Continued.*

Plot F. Treatment. Spray I, II. 2:4 Bordeaux and 2 lbs. arsenate of lead per barrel.

			FIRST BROOD				SECOND BROOD				TOTAL			
Tree.		Total Apples	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
F62	D.	480	7		3		17		14		24		17	
	T.	1542	13	**35.1**	7	**53**	24	**64.9**	20	**83.3**	37	**2.3**	27	**73**
F63	D.	428	18		11		15		15		33		26	
	T.	1288	20	**43.4**	13	**65**	26	**56.6**	26	**100**	46	**3.5**	39	**84**
F64	D.	637	23		19		17		13		40		32	
	T.	2016	27	**46.5**	21	**77.7**	31	**53.5**	25	**80.1**	58	**2.8**	46	**80**
F65	D.	833	38		21		20		15		58		36	
	T.	2748	46	**56.7**	27	**58.6**	35	**43.3**	29	**82.9**	81	**2.9**	56	**69**
F66	D.	895	21		19		19		16		40		35	
	T.	2262	28	**45.9**	23	**82.1**	33	**54.1**	29	**87.8**	61	**2.6**	52	**85**
F67	D.	289	10		9		8		8		18		17	
	T.	871	17	**50**	16	**94.7**	17	**50**	17	**100**	34	**3.9**	33	**97**
Total	D.	3562	117		82		96		81		213		163	
	T.	10727	151	**47.6**	107	**70.8**	166	**52.4**	146	**88.5**	317	**2.9**	253	**79**

Injury by Codling Moth in orchard of John Smith, Deerfield, N. H. in 1907.

Plot H-20. No Treatment.

101	D.	328	45		9		6		0		51		9	
	T.	391	49	**85.9**	9	**18.3**	8	**14.1**	0	**0**	57	**14.5**	9	**15**
102	D.	297	25		6		6		3		31		9	
	T.	321	25	**80.6**	6	**25**	6	**19.4**	3	**50**	31	**9.6**	9	**29**
103	D.	340	29		9		4		3		33		12	
	T.	343	29	**87.8**	9	**31**	4	**12.2**	3	**75**	33	**9.6**	12	**36**
104	D.	367	48		13		5		4		53		17	
	T.	369	48	**90.5**	13	**27**	5	**9.5**	4	**80**	53	**14.3**	17	**32**
105	D.	1089	121		32		8		3		129		35	
	T.	1152	124	**93.9**	32	**25.8**	8	**6.1**	3	**37.5**	132	**11.4**	35	**36**
Total	D.	2421	268		69		29		13		297		82	
	T.	2576	275	**89.9**	69	**25**	31	**10.1**	13	**41.9**	306	**11.8**	82	**26**

TABLE 8.—*Concluded.*

Plot 14. Treatment, Spray I, II. 2 lbs. arsenate of lead and 4:4 Bordeaux mixture per barrel.

			FIRST BROOD				SECOND BROOD				TOTAL			
Tree:		Total Apples	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent
68	D.	55	11		7		4		3		15		10	
	T.	159	14	70	8	57.1	6	30	5	83.3	20	12.5	13	65
69	D.	790	28		11		6		5		33		16	
	T.	1860	32	59.2	14	43.6	22	40.8	17	77.2	54	2.9	31	57
70	D.	204	36		11		10		8		46		19	
	T.	768	56	69.1	15	26.7	25	30.9	21	84	81	10.5	36	44
71	D.	557	29		13		7		5		36		18	
	T.	2251	41	53.9	18	43.9	35	46.1	29	82.8	76	3.3	47	61
72	D.	740	60		45		5		1		70		46	
	T.	1736	73	90.1	58	79.4	8	9.9	4	50	81	4.6	62	76
Total	D.	2346	164		87		32		22		196		109	
	T.	6774	216	69.3	113	52.3	96	30.7	76	79.1	312	4.6	189	60

Plot 16. Treatment, Spray I. 2 lbs. arsenate of lead and 2:4 Bordeaux mixture per barrel.

77	D.	565	18		10		5		4		23		14	
	T.	1768	47	**88.6**	28	**59.5**	6	**11.4**	5	**83.3**	53	**2.9**	33	**62**
78	D.	381	23		11		6		4		29		15	
	T.	1707	53	**84.2**	34	**64.1**	10	**15.8**	8	**80**	63	**3.6**	42	**66**
79	D.	679	24		8		3		3		27		11	
	T.	2429	56	**83.5**	29	**51.7**	11	**16.5**	11	**100**	67	**2.7**	40	**59**
80	D.	651	35		9		5		5		40		14	
	T.	2433	83	**84.6**	41	**49.3**	15	**15.4**	11	**73.3**	98	**4**	52	**53**
81	D.	275	26		12		1		1		27		13	
	T.	1190	52	**85.2**	25	**48**	9	**14.8**	9	**100**	61	**5.1**	34	**55**
82	D.	525	56		21		7		5		63		26	
	T.	1216	75	**90.3**	31	**41.3**	8	**9.7**	6	**75**	83	**6.8**	37	**44**
Total	D.	3076	182		71		27		22		209		93	
	T.	1074	366	**88.5**	188	**51.3**	59	**11.5**	50	**84.7**	425	**3.9**	238	**56**

TABLE 9. *Injury by Codling Moth in Orchard of W. A. Deering, Pittsfield, N. H., in* 1907.

Plot C. No Treatment.

Tree.		Total Apples	First Brood Total Wormy	Per cent.	Side Wormy	Per cent.	Second Brood Total Wormy	Per cent.	Side Wormy	Per cent.	Total Total Wormy	Per cent.	Side Wormy	Per cent.
C2	D.	379	91		41		33		27		124		68	
	T.	875	94	**40**	42	**44**	137	**60**	109	**80**	231	**26**	151	**65**
C3	D.	804	174		62		51		43		225		105	
	T.	1554	176	**45**	62	**35**	211	**55**	172	**82**	387	**25**	234	**60**
C5	D.	1021	276		95		83		61		359		154	
	T.	2410	279	**46**	95	**34**	316	**54**	236	**74**	595	**24**	331	**55**
C7	D.	828	154		38		72		55		226		93	
	T.	1856	159	**46**	39	**24**	186	**54**	144	**77**	345	**18**	183	**53**
C3	D.	1148	219		70		63		45		282		115	
	T.	2345	221	**57**	71	**32**	162	**43**	125	**77**	383	**16**	196	**51**
Total	D.	4180	914		306		302		231		1216		537	
	T.	9040	929	**48**	309	**33**	1012	**52**	786	**78**	1941	**21**	1095	**55**
Plot A. Treatment, Sprays I, II, III. 3:4 Bordeaux only.														
A2	D.	1571	234		60		62		52		296		112	
	T.	2526	234	**52**	60	**25**	212	**48**	146	**69**	446	**17**	206	**46**
A3	D.	1250	217		49		45		28		262		77	
	T.	1490	218	**69**	49	**22**	94	**31**	66	**70**	312	**21**	115	**37**
A4	D.	488	96		43		91		68		187		111	
	T.	1481	96	**50**	43	**44**	96	**50**	71	**72**	192	**13**	114	**59**
Total	D.	3309	547		152		198		148		745		300	
	T.	5497	548	**57**	152	**27**	402	**43**	283	**70**	950	**17**	435	**45**

Plot 1. Treatment, Sprays I, II mist. 2 lbs. arsenate of lead and 3:4 Bordeaux per barrel.

11	D.	316	10		1		3		2		13		3	
	T.	977	10	**38**	1	**10**	16	**62**	13	**81**	26	**2.6**	14	**53**
12	D.	715	33		2		3		2		36		4	
	T.	921	33	**86**	2	**6**	5	**14**	3	**60**	38	**4.1**	5	**13**
13	D.	89	6		1		1		1		7		2	
	T.	276	6	**66**	1	**16**	3	**33**	3	**100**	9	**3.2**	4	**44**
14	D.	1994	56		5		13		9		69		14	
	T.	3149	56	**64**	5	8.9	31	**36**	25	**80**	87	**2.8**	30	**34**
16	D.	1754	40		5		2		0		42		5	
	T.	2593	40	**83**	5	**12**	8	**17**	6	**75**	48	**1.8**	11	**23**
18	D.	1317	26		6		2		2		28		8	
	T.	2712	27	**66**	7	**26**	15	**34**	13	**92**	42	**1.5**	20	**47**
19	D.	1492	35		3		5		2		40		5	
	T.	2814	35	**70**	3	8.5	15	**30**	12	**80**	50	**1.7**	15	**30**
Total	D.	7677	206		23		29		18		235		41	
	T.	13442	206	**69**	24	**11**	93	**31**	75	**81**	299	**2.2**	99	**33**

TABLE 9.—*Continued.*

Plot 2. Treatment, Sprays I, II drenched 2 lbs. arsenate of lead and 3:4 Bordeaux per barrel.

			FIRST BROOD				SECOND BROOD				TOTAL			
Tree.		Total Apples	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
210	D.	130	3		0		0		0		3		0	
	T.	497	3	**100**	0	**0**	0	**0**	0	**0**	3	**.6**	0	**0**
211	D.	359	10		1		0		0		10		1	
	T.	928	10	**59**	1	**10**	7	**41**	7	**100**	17	**1.8**	8	**47**
212	D.	647	15		2		1		1		16		3	
	T.	1497	15	**60**	2	**13**	10	**40**	9	**90**	25	**1.6**	11	**44**
213	D.	10	1		1		0		0		1		1	
	T.	115	1	**100**	1	**100**	0	**0**	0	**0**	1	**.9**	1	**100**
214	D.	103	5		2		3		3		8		5	
	T.	166	5	**55**	2	**40**	4	**45**	4	**100**	9	**5.6**	6	**66**
215	D.	184	2		0		3		2		5		2	
	T.	419	2	**40**	0	**0**	3	**60**	2	**66**	5	**1.1**	2	**40**
216	D.	255	4		3		12		12		16		15	
	T.	569	4	**22**	3	**75**	14	**78**	13	**92**	18	**3.1**	16	**88**
217	D.	225	3		1		12		12		15		13	
	T.	533	3	**18**	1	**33**	13	**82**	12	**93**	16	**3**	13	**81**
Total	D.	1913	43		10		31		30		74		40	
	T.	4724	43	**45**	10	**23**	51	**55**	47	**93**	94	**2**	57	**60**

Plot 3 and Plot B. Treatment, Sprays I, II, III. 2 lbs. arsenate of lead and 3:4 Bordeaux per barrel.

318	D.	13	1		1		0		0		1		1	
	T.	33	1	**100**	1	**100**	0	**0**	0	**0**	1	**3**	1	**100**
320	D.	273	6		3		0		0		6		3	
	T.	934	6	**100**	3	**50**	0	**0**	0	**0**	6	**.64**	3	**50**
322	D.	40	1		1		1		1		2		2	
	T.	321	1	**50**	1	**100**	1	**50**	1	**100**	2	**.6**	2	**100**
323	D.	226	3		1		0		0		3		1	
	T.	508	3	**75**	1	**33**	1	**25**	1	**100**	4	**.8**	2	**50**
324	D.	116	3		1		0		0		3		1	
	T.	501	3	**60**	1	**33**	2	**40**	2	**100**	5	**1**	3	**60**
Total	D.	668	14		7		1		1		15		8	
	T.	2297	14	**77**	7	**50**	4	**23**	4	**100**	18	**.78**	11	**61**
B2	D.	1237	26		5		3		3		29		8	
	T.	2767	26	**55**	5	**18**	21	**45**	21	**100**	47	**1.7**	26	**55**
B4	D.	300	12		8		4		4		16		12	
	T.	771	12	**70**	8	**66**	5	**30**	4	**80**	17	**2.2**	12	**70**
Total	D.	1537	38		13		7		7		45		20	
	T.	3538	38	**59**	13	**32**	26	**41**	25	**96**	64	**1.8**	38	**60**
Total Plots 3 and B.				**63**		**38**		**37**		**96**		**1.4**		

TABLE 9.—*Continued.*

Plot 13. Treatment, Sprays I, II, III. 2 lbs. arsenate of lead per barrel.

Tree.		Total Apples	FIRST BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	SECOND BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	TOTAL Total Wormy	Per cent.	Side Wormy	Per cent.
1386	D.	149	3		2		1		1		4		3	
	T.	989	3	**30**	2	**66**	7	**70**	7	**100**	10	**1**	9	**90**
1387	D.	745	18		2		2		2		20		4	
	T.	2449	18	**81**	2	**11**	4	**19**	4	**100**	22	**.9**	6	**·27**
1391	D.	151	2		1		0		0		2		1	
	T.	1076	2	**50**	1	**50**	2	**50**	2	**100**	4	**.4**	3	**75**
1397	D.	198	1		0		3		0		4		0	
	T.	801	1	**14**	0	**0**	6	**86**	2	**33**	7	**.9**	2	**28**
13102	D.	80	5		4		0		0		5		4	
	T.	220	5	**62**	4	**80**	3	**38**	2	**66**	8	**3.6**	6	**75**
Total	D.	1323	29		9		6		3		35		12	
	T.	5535	29	**56**	9	**31**	22	**44**	17	**77**	49	**.9**	26	**53**

Plot. North row of Plots 14 and 15. Treatment same as Plot 13.

Tree.		Total Apples	FIRST BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	SECOND BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	TOTAL Total Wormy	Per cent.	Side Wormy	Per cent.
14113	D.	453	46		14		36		30		82		44	
	T.	959	46	**41**	14	**30**	64	**59**	52	**81**	110	**11**	66	**60**
15124	D.	564	19		4		0		0		19		4	
	T.	1051	19	**73**	4	**21**	7	**37**	7	**100**	26	**2.5**	11	**42**
Total	D.	1017	65		18		36		30		101		48	
	T.	2010	65	**47**	18	**27**	71	**53**	59	**83**	136	**6.8**	77	**56**

Plots 8, 9, 10, 11 and 12. Treatment, Sprays I, II. 2 lbs. arsenate of lead and benzoate of soda bordeaux mixtures.

Plot.	Trees.														
8	12	D.	2363	119		52		52		47		171		99	
		T.	6717	119	**52**	52	**43**	110	**48**	99	**90**	229	**3.4**	151	**65**
9	6	D.	956	41		18		14		13		55		31	
		T.	2977	51	**60**	19	**37**	34	**40**	30	**88**	85	**2.8**	49	**57**
10	5	D.	1234	25		12		7		7		32		19	
		T.	2772	28	**65**	15	**52**	15	**35**	14	**93**	43	**1.5**	29	**67**
11	6	D.	1339	56		21		18		15		74		36	
		T.	4518	57	**40**	22	**39**	85	**60**	76	**90**	142	**2**	98	**69**
12	6	D.	362	18		8		0		0		18		8	
		T.	1503	19	**61**	8	**42**	12	**39**	12	**100**	31	**2**	20	**64**
Total	35	D.	6254	259		111		94		82		350		193	
		T.	18487	274	**51**	116	**42**	256	**49**	231	**90**	530	**2.8**	347	**65**

Plot 14. Treatment, Spray V. 2 lbs. arsenate of lead per barrel.

109		D.	69	6		5		14		9		20		14	
		T.	258	6	**15**	5	**83**	34	**85**	25	**73**	40	**14**	30	**75**
112		D.	116	28		16		15		5		43		21	
		T.	1151	31	**38**	17	**54**	50	**52**	35	**70**	81	**7**	52	**64**
115		D.	71	6		4		5		1		11		5	
		T.	183	6	**38**	4	**66**	10	**62**	6	**60**	16	**8.8**	10	**62**
116		D.	386	55		29		19		14		74		43	
		T.	744	58	**58**	29	**50**	42	**42**	32	**78**	100	**13**	61	**61**
Total		D.	642	95		54		53		29		148		83	
		T.	2336	101	**42**	55	**55**	136	**58**	98	**72**	237	**10**	153	**64**

TABLE 9.—*Continued.*

Tree.		Total Apples	First Brood: Total Wormy	First Brood: Per cent.	First Brood: Side Wormy	First Brood: Per cent.	Second Brood: Total Wormy	Second Brood: Per cent.	Second Brood: Side Wormy	Second Brood: Per cent.	Total: Total Wormy	Total: Per cent.	Total: Side Wormy	Total: Per cent.
Plot 15. Treatment, Spray V. 2 lbs. arsenate of lead and 3 lbs. resin soap per barrel.														
123	D.	104	16		4		12		8		28		12	
	T.	166	16	**53**	4	**25**	14	**47**	10	**71**	30	**18**	14	**46**
126	D.	338	26		14		22		16		48		30	
	T.	1314	28	**29**	14	**50**	68	**71**	51	**75**	96	**7.3**	65	**66**
129	D.	287	19		13		19		14		38		27	
	T.	1126	22	**20**	14	**63**	86	**80**	68	**78**	108	**9.6**	82	**76**
131	D.	212	27		17		65		52		92		69	
	T.	863	27	**17**	17	**63**	129	**83**	103	**78**	156	**18**	130	**83**
Total	D.	941	88		48		118		90		206		138	
	T.	3469	93	**24**	49	**52**	297	**76**	232	**78**	390	**11**	281	**72**
Plots 14 and 15, average				**30**		**53**		**70**		**74**		**10**		
Plot 6. Treatment, Sprays I, II. Paris green 1-3 lb. and Copper Phosphate 10 lbs. per barrel.														
638	D.	507	20		1		3		3		23		4	
	T.	1255	21	**36**	1	**4.7**	36	**64**	30	**83**	57	**4.5**	31	**54**
639	D.	134	2		2		4		4		6		6	
	T.	887	2	**22**	2	**100**	7	**78**	6	**85**	9	**1**	8	**88**
641	D.	333	5		3		3		3		8		6	
	T.	1687	5	**55**	3	**60**	4	**45**	4	**100**	9	**.5**	7	**77**
642	D.	961	16		2		5		5		21		7	
	T.	2553	17	**39**	3	**17**	26	**61**	24	**92**	43	**1.7**	27	**63**
Total	D.	1935	43		8		15		15		58		23	
	T.	6382	45	**38**	9	**20**	73	**62**	64	**87**	118	**1.8**	73	**62**

Plot 7. Treatment, Sprays I, II,, same as Plot 6 with Lime added.

743	D.	529	11		3		6		6		17		9	
	T.	1957	11	**42**	3	**27**	15	**58**	14	**93**	26	**1.3**	17	**65**
744	D.	449	11		1		2		2		13		3	
	T.	873	11	**42**	1	**9**	15	**58**	14	**93**	26	**1.8**	15	**58**
745	D.	867	18		4		6		6		24		10	
	T.	2977	18	**54**	4	**22**	15	**46**	15	**100**	33	**1.1**	19	**59**
746	D.	700	10		0		6		6		16		6	
	T.	1779	10	**38**	0	**0**	16	**62**	16	**100**	26	**1.4**	16	**61**
747	D.	1031	31		12		5		4		36		16	
	T.	2911	32	**45**	13	**40**	38	**55**	37	**97**	70	**2.4**	50	**71**
748	D.	1183	25		3		7		7		32		10	
	T.	2970	25	**34**	3	**12**	42	**66**	40	**95**	67	**2.6**	43	**64**
Total	D.	4759	106		23		32		31		138		54	
	T.	13467	107	**43**	24	**24**	141	**57**	136	**96**	248	**1.8**	150	**60**
Plots 6 and 7, total average.				**41**		**22**		**59**		**93**		**1.8**		

TABLE 9.—*Concluded.*

Plot 5. Treatment, Sprays I, II, with 1-3 lb. Paris green and 2:4 Bordeaux and spray III with Kerosene-limoid-bordeaux, 10 per cent. kerosene and 1-3 lb. of Paris green per barrel.

			FIRST BROOD				SECOND BROOD				TOTAL			
Tree.		Total Apples	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
533	D.	153	9		1		2		2		11		3	
	T.	666	12	**45**	3	**25**	14	**55**	12	**85**	26	**3.9**	15	**58**
534	D.	460	11		3		3		2		14		5	
	T.	1598	11	**45**	3	**27**	13	**55**	11	**84**	24	**1.5**	14	**58**
535	D.	675	19		3		3		2		22		5	
	T.	2240	19	**22**	3	**15**	67	**78**	65	**97**	86	**3.9**	68	**79**
536	D.	671	52		16		25		21		77		37	
	T.	2591	53	**44**	16	**30**	69	**66**	60	**85**	122	**4.7**	76	**62**
537	D.	623	15		2		5		5		20		7	
	T.	2783	16	**32**	2	**12**	34	**68**	32	**94**	50	**1.4**	34	**68**
Total	D.	2582	106		25		38		32		144		57	
	T.	9878	111	**36**	27	**24**	197	**64**	180	**91**	307	**3.1**	207	**66**

Plot 4. Treatment, Sprays I, II, III, 1-3 lb. Paris green and 2:4 Bordeaux per barrel.

426	D.	199	4		4		4		3		8		7	
	T.	812	4	**40**	4	**100**	6	**60**	4	**66**	10	**1.2**	8	**80**
427	D.	31	0		0		2		1		2		1	
	T.	162	0	**0**	0	**0**	4	**100**	3	**75**	4	**2.5**	3	**75**
428	D.	203	6		1		0		0		6		1	
	T.	704	6	**50**	1	**16**	6	**50**	5	**83**	12	**1.7**	6	**50**
429	D.	109	3		1		1		1		4		2	
	T.	419	3	**43**	1	**33**	4	**57**	4	**100**	7	**1.6**	5	**71**
431	D.	94	1		1		2		1		3		2	
	T.	244	1	**33**	1	**100**	2	**66**	1	**100**	3	**1.2**	2	**66**
432	D.	475	10		4		13		12		23		16	
	T.	1504	10	**39**	4	**40**	16	**61**	15	**93**	26	**1.6**	19	**73**
4S	D.	114	8		3		3		3		11		6	
	T.	358	8	**61**	3	**37**	5	**29**	4	**80**	13	**3.6**	7	**54**
Total	D.	1225	32		14		25		21		57		35	
	T.	4203	32	**42**	14	**43**	43	**58**	36	**83**	75	**1.7**	50	**66**
Plots 4 and 5, total average.				**37**		**28**		**63**		**85**		**2.7**		

TABLE 10. *Injury by the Codling Moth in the Orchard of Gilman Woodman, Durham, N. H. in 1907.*

Plot C. No Treatment.

Tree.		Total Apples	FIRST BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	SECOND BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	TOTAL Total Wormy	Per cent.	Side Wormy	Per cent.
C1	D.	2041	317		77		62		45		379		121	
	T.	6796	342	**32**	100	**29**	724	**68**	390	**54**	1066	**14**	490	**46**
C3	D.	1017	217		66		43		16		260		82	
	T.	4278	236	**25**	72	**30**	395	**75**	296	**42**	931	**21**	368	**40**
C5	D.	2799	583		190		139		75		722		265	
	T.	8458	625	**32**	214	**34**	1313	**68**	437	**33**	1938	**23**	651	**33**
C6	D.	709	148		23		125		32		273		55	
	T.	1255	153	**26**	24	**15**	421	**74**	58	**13**	574	**46**	82	**14**
C7	D.	398	74		30		65		34		139		64	
	T.	942	81	**21**	34	**42**	302	**79**	118	**39**	383	**40**	152	**40**
C8	D.	2450	479		131		111		55		590		186	
	T.	8301	556	**31**	161	**29**	1235	**69**	367	**29**	1791	**21**	528	**30**
C9	D.	1725	353		78		194		86		547		164	
	T.	6029	408	**27**	94	**23**	1099	**73**	273	**25**	1507	**25**	367	**24**
Total	D.	11139	2171		595		739		343		2910		938	
	T.	36059	2401	**29**	699	**29**	5789	**71**	1939	**33**	8190	**22.7**	2638	**32**

Plot 1. Treatment, Spray I, mist, 2 lbs. arsenate of lead.

11	D.	750	9		2		13		11		22		13	
	T.	3575	12	**18**	5	**41**	55	**82**	48	**87**	67	**1.9**	53	**79**
12	D.	781	9		3		12		11		21		14	
	T.	4990	12	**26**	6	**50**	33	**74**	30	**90**	45	**.9**	36	**80**
13	D.	1230	24		6		22		16		46		22	
	T.	6087	27	**31**	8	**30**	59	**59**	43	**72**	86	**1.4**	51	**59**
14	D.	1186	12		8		23		17		35		25	
	T.	6471	12	**8.5**	8	**66**	128	**91.5**	92	**70**	140	**2**	100	**71**
16	D.	788	25		6		53		32		78		38	
	T.	3193	30	**25**	10	**33**	91	**75**	68	**74**	121	**4**	78	**65**
Total	D.	4735	79		25		123		87		202		112	
	T.	24316	93	**20**	37	**39**	366	**80**	281	**76**	459	**1.88**	318	**69**

Plot 2. Treatment, Spray I, drenched, 2 lbs. arsenate of lead.

22	D.	210	9		4		3		3		12		7	
	T.	2446	10	**26**	4	**40**	28	**74**	25	**89**	38	**1.5**	29	**76**
17	D.	370	17		6		6		6		23		12	
	T.	2865	21	**36**	9	**43**	37	**64**	31	**83**	58	**2**	40	**69**
16	D.	81	12		3		10		9		22		12	
	T.	500	15	**14**	4	**26**	90	**86**	29	**32**	105	**21**	33	**31**
14	D.	676	30		4		3		3		33		7	
	T.	2298	30	**39**	4	**13**	46	**61**	39	**84**	76	**3.2**	43	**56**
Total	D.	1337	68		17		22		21		90		38	
	T.	8109	76	**28**	21	**27**	201	**72**	124	**61**	277	**3.4**	145	**52**

TABLE 10.—*Continued.*

Plot 4 B. Treatment, Spray I with atomizer. 2 lbs, arsenate of lead per barrel.

Tree.		Total Apples	First Brood Total Wormy	First Brood Per cent.	First Brood Side Wormy	First Brood Per cent.	Second Brood Total Wormy	Second Brood Per cent.	Second Brood Side Wormy	Second Brood Per cent.	Total Total Wormy	Total Per cent.	Total Side Wormy	Total Per cent.
442	D.	220	25		13		6		6		31		19	
	T.	2424	25	**27**	13	**51**	65	**73**	44	**67**	90	**3.7**	57	**63**
443	D.	482	57		19		18		14		75		33	
	T.	2711	57	**39**	19	**33**	87	**61**	55	**63**	144	**5.3**	74	**51**
444	D.	1340	156		36		107		82		263		118	
	T.	4386	159	**33**	36	**23**	315	**67**	161	**51**	474	**10**	197	**41**
445	D.	904	93		27		38		22		131		49	
	T.	2839	94	**27**	27	**28**	247	**73**	110	**44**	341	**12**	137	**40**
Total	D.	2946	331		95		169		124		500		229	
	T.	12360	335	**32**	95	**28**	714	**68**	370	**51**	1049	**8.5**	465	**44**
		Plot 5. Treatment, Spray II. 2 lbs. arsenate of lead per barrel.												
555	D.	826	253		69		67		45		320		114	
	T.	2534	256	**53**	70	**28**	241	**47**	134	**55**	497	**19**	204	**40**
556	D.	626	138		33		38		27		176		60	
	T.	2921	139	**35**	34	**24**	252	**65**	124	**50**	491	**13**	158	**32**
557	D.	548	107		35		53		33		160		68	
	T.	2755	109	**19**	36	**33**	456	**81**	199	**43**	565	**20**	235	**41**
558	D.	607	158		43		46		32		204		75	
	T.	2846	163	**31**	43	**27**	343	**69**	154	**44**	506	**17**	197	**39**
559	D.	147	52		9		14		10		66		19	
	T.	481	54	**27**	10	**18**	141	**73**	58	**41**	195	**40**	68	**34**
Total	D.	2754	708		189		218		147		926		336	
	T.	11537	721	**33**	195	**26**	1433	**67**	669	**46**	2154	**18**	864	**40**

Plot 6. Treatment, Spray III. 2 lbs. arsenate of lead per barrel.

673	D.	216	74		12		24		9		83		21	
	T.	968	75	**30**	13	**17**	175	**70**	74	**42**	250	**25**	87	**34**
674	D.	1076	163		54		34		21		197		75	
	T.	3376	166	**39**	55	**33**	251	**61**	123	**49**	417	**12**	178	**42**
675	D.	880	112		23		23		10		135		33	
..	T.	2426	113	**37**	24	**21**	193	**63**	92	**50**	306	**12**	178	**42**
676	D.	1113	192		46		20		11		212		57	
	T.	3808	196	**46**	48	**24**	226	**61**	87	**38**	422	**11**	135	**32**
677	D.	22	8		1		0		0		8		1	
	T.	248	11	**14**	2	**18**	65	**86**	24	**37**	76	**30**	26	**33**
Total	D.	3307	549		136		101		51		650		187	
	T.	10826	561	**38**	142	**25**	910	**62**	400	**44**	1471	**13**	542	**30**
Average 674—676				**41**		**25**		**59**		**45**		**12**		

TABLE 10.—*Continued.*

Plot 4A. Treatment, Spray III, in usual manner from above; 2 lbs. arsenate of lead per barrel.

			FIRST BROOD				SECOND BROOD				TOTAL			
Tree.		Total Apples	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
439	D.	824	94		19		21		17		115		36	
	T.	5278	107	**51**	29	**27**	103	**49**	31	**30**	210	**4**	60	**27**
440	D.	1134	89		21		6		4		95		25	
	T.	5556	112	**52**	36	**32**	102	**48**	18	**17**	214	**3.9**	54	**25**
441	D.	932	77		20		8		6		85		26	
	T.	4690	77	**37**	20	**26**	128	**63**	52	**40**	205	**4.3**	72	**35**
Total	D.	2890	260		60		35		27		295		87	
	T.	15524	296	**47**	85	**29**	333	**33**	101	**30**	629	**4**	186	**29**

Plot 4B. Treatment, Spray III, from above and below; 2 lbs. arsenate of lead per barrel.

446	D.	1165	97		19		8		5		105		24	
	T.	4197	not recorded											
447	D.	1054	121		17		13		5		134		22	
	T.	3991	121	**71**	17	**14**	48	**29**	23	**49**	169	**4.2**	40	**24**

Plot 4D. Treatment. Same as Plot 4A plus 3 lbs. resin soap per barrel.

437	D.	871	95		23		21		16		116		39	
	T.	4289	102	**57**	27	**26**	76	**43**	27	**35**	178	**4.1**	54	**30**
438	D.	692	67		25		8		7		75		32	
	T.	3817	73	**68**	30	**41**	33	**32**	9	**27**	110	**2.7**	39	**35**
Total	D.	1563	162		48		29		23		191		71	
	T.	8106	175	**61**	57	**32**	109	**39**	36	**33**	284	**2.8**	93	**33**

Plot 4C. Treatment. Same as Plot 4A but apples bagged during spraying.

448	D.	1696	205		45		24		19		229		64	
	T.	3924	206	**49**	45	**21**	211	**51**	88	**41**	417	**10.7**	133	**31**

Plot 3. Treatment, Sprays I and III. 2 lbs. arsenate of lead per barrel.

330	D.	453	20		7		8		7		28		14	
	T.	3332	21	**36**	8	**38**	36	**64**	32	**90**	57	**1.7**	40	**88**
331	D.	527	11		3		3		3		14		6	
	T.	2867	12	**33**	4	**33**	24	**67**	22	**91**	36	**1.3**	26	**72**
332	D.	505	13		8		7		7		20		15	
	T.	3135	13	**26**	8	**61**	47	**74**	41	**87**	60	**1.9**	49	**81**
Total	D.	1485	44		18		18		17		62		35	
	T.	9334	46	**30**	20	**43**	107	**70**	95	**88**	153	**1.6**	115	**74**

Plot B. Treatment, Sprays I, II, III. 2 lbs. arsenate of lead per barrel.

B1	D.	1300	28		7		0		0		28		7	
	T.	2832	28	**70**	7	**25**	12	**30**	9	**75**	40	**1.4**	16	**40**
B2	D.	876	29		4		11		11		40		15	
	T.	5636	29	**53**	4	**14**	25	**47**	25	**100**	54	**.9**	29	**53**
B3	D.	331	15		4		6		6		21		10	
	T.	5739	15	**51**	4	**26**	14	**49**	14	**100**	29	**.5**	18	**62**
B4	D.	573	17		2		2		2		19		4	
	T.	5153	18	**66**	3	**15**	9	**33**	9	**100**	27	**.5**	12	**44**
B5	D.	364	10		7		10		10		20		17	
	T.	4377	10	**18**	7	**70**	46	**82**	41	**89**	56	**1.2**	48	**85**
Total	D.	3444	99		24		29		29		128		53	
	T.	23737	100	**48**	25	**25**	106	**52**	98	**97**	206	**.9**	123	**60**

TABLE 10.—*Concluded.*

Plot A. Treatment, Sprays I, III, V. 2 lbs. arsenate of lead per barrel.

			FIRST BROOD				SECOND BROOD				TOTAL			
Tree.		Total Apples	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
A3	D.	778	26		3		8		7		34		10	
	T.	1897	26	**54**	3	**11**	22	**46**	20	**89**	48	**2**	23	**48**
A4	D.	1855	66		8		11		11		77		19	
	T.	6858	68	**56**	9	**13**	52	**44**	48	**92**	120	**1.7**	57	**47**
A5	D.	216	7		1		3		3		10		4	
	T.	1063	8	**47**	2	**25**	9	**53**	8	**88**	17	**1.7**	10	**58**
A6	D.	1243	106		4		9		9		115		13	
	T.	3972	108	**75**	5	**4.6**	36	**25**	34	**94**	144	**3.6**	39	**27**
A7	D.	843	29		9		13		11		42		20	
	T.	3771	30	**43**	9	**30**	40	**57**	37	**92**	70	**1.8**	46	**65**
Total	D.	4935	234		25		44		41		278		66	
	T.	17561	240	**60**	28	**11**	159	**40**	147	**92**	399	**2.2**	175	**43**

TABLE 11. *Injury by the Codling Moth in the Orchard of W. A. Deering, Pittsfield, N. H. in 1908.*

Plot C. No Treatment.

		FIRST BROOD				SECOND BROOD				TOTAL			
Tree.	Total Apples*	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
C1	70	58	**96.6**	23	**39.6**	2	**3.4**	2	**100**	60	**85.7**	25	**41.6**
C2	102	43	**100**	21	**48.8**	0	**0**	0	**0**	43	**42.1**	21	**48.8**
C3	276	80	**75.4**	35	**43.7**	26	**24.6**	20	**74.6**	106	**38.4**	55	**51.8**
C4	925	**235**	**60.1**	116	**49.2**	156	**39.9**	145	**92.9**	391	**42.2**	251	**64.1**

C5	306	113	62	53	47	54	38	51	94	167	54	104	62
C6	398	180	76	92	51	57	24	24	70	237	59	220	93
C7	542	255	78	101	40	71	22	67	94	326	60	168	51
C8	690	160	65	74	46	85	35	69	81	245	35	143	58
Total	3309	1124	71	515	46	451	29	404	89	1575	47	919	58

Plot B. Treatment, Sprays I, III. 2 lbs. arsenate of lead per barrel.

B 1	1231	32	38	27	84	51	61	45	88	83	8	72	87
B 2	799	22	32	19	86	44	68	38	86	66	8	57	86
B 3	813	26	39	20	77	41	61	32	78	67	8	52	78
B 4	1098	13	41	12	92	19	59	17	89	32	3	29	91
B 5	697	13	43	11	85	17	57	17	100	30	4	28	93
B 6	999	10	37	5	50	17	63	16	94	27	3	21	78
B 7	582	11	33	9	82	22	67	21	95	33	6	30	91
B 8	434	31	49	18	86	22	51	22	100	43	10	40	93
B 9	609	18	49	18	100	19	59	19	100	37	6	37	100
B10	626	25	36	20	80	45	64	43	95	70	11	63	90
Total	7888	191	39	159	83	297	61	270	91	488	6	429	88

* Dropped and picked.

TABLE 11.—*Continued.*

Plot 1. Treatment, Spray I, mist. 2 lbs. arsenate of lead per barrel.

		FIRST BROOD				SECOND BROOD				TOTAL			
Tree.	Total Apples*	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
1—1	207	26	**67**	23	**88**	13	**33**	9	**69**	39	**19**	32	**82**
1—2	21	5	**83**	5	**100**	1	**16**	1	**100**	6	**28**	6	**100**
1—3	405	34	**62**	19	**66**	21	**38**	18	**86**	55	**13**	37	**67**
1—4	794	118	**80**	74	**63**	30	**20**	24	**80**	148	**19**	98	**66**
1—5	930	40	**56**	38	**95**	31	**44**	31	**100**	71	**8**	69	**97**
1—6	300	16	**80**	15	**94**	4	**20**	4	**100**	20	**7**	19	**95**
Total	2657	239	**70**	174	**73**	97	**29**	87	**90**	339	**13**	261	**77**

Plot 1A. Treatment. Same as Plot 1 but sprayed with atomizer.

		FIRST BROOD				SECOND BROOD				TOTAL			
Tree.	Total Apples*	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
A—1	419	31	**52**	29	**93**	28	**47**	25	**89**	59	**14**	54	**91**
A—2	907	22	**61**	21	**95**	14	**39**	13	**93**	36	**4**	34	**94**
A—3	271	21	**72**	18	**86**	8	**28**	6	**75**	29	**11**	24	**83**
A—4	1032	33	**43**	28	**85**	44	**57**	42	**95**	77	**7**	70	**91**
Total	2629	107	**53**	96	**90**	94	**47**	86	**91**	201	**8**	182	**90**

		Plot 2. Treatment, Spray I, drenched. 2 lbs. arsenate of lead per barrel.										
2—1	167	10	**67**	10	**100**	5	**33**	0	**0**	15	**9**	10	**67**
2—2	814	20	**46**	19	**95**	23	**53**	23	**100**	43	**5**	42	**95**
2—3	528	13	**30**	2	**92**	30	**70**	29	**97**	43	**8**	41	**95**
2—4	110	34	**100**	30	**88**	0	**0**	0	**0**	34	**3**	30	**88**
2—5	244	14	**32**	13	**93**	29	**67**	28	**96**	43	**18**	41	**95**
2—6	297	13	**54**	12	**92**	11	**46**	11	**100**	24	**8**	23	**96**
Total	2160	106	**52**	96	**90**	98	**48**	96	**98**	202	**9**	192	**95**
	Plot 3A. Treatment, Spray III. 2 lbs. arsenate of lead. Apples bagged during spraying.												
3—1	69	24	**86**	9	**37**	4	**14**	3	**75**	28	**40**	12	**43**
3—2	81	39	**75**	21	**54**	13	**25**	12	**92**	52	**64**	33	**63**
3—3	53	23	**79**	12	**52**	6	**21**	5	**83**	29	**55**	17	**59**
3—4	230	75	**77**	43	**59**	22	**23**	20	**91**	97	**42**	63	**65**
3—5	245	28	**78**	19	**68**	8	**22**	8	**42**	36	**15**	27	**75**
Total	668	**189**	**78**	104	**55**	53	**22**	48	**90**	242	**36**	152	**63**

* Dropped and picked.

TABLE 11.—*Concluded.*

Plot 3. Treatment, Spray III. 2 lbs. arsenate of lead per barrel.

		FIRST BROOD				SECOND BROOD				TOTAL			
Tree.	Total Apples*	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
3—6	746	33	**49**	22	**67**	34	**51**	32	**94**	67	**9**	54	**80**
3—7	260	21	**70**	10	**48**	9	**30**	9	**100**	30	**11**	19	**63**
3—8	128	11	**55**	9	**82**	9	**45**	9	**100**	20	**16**	18	**90**
3—9	278	21	**60**	14	**67**	14	**40**	14	**100**	35	**12**	28	**80**
3—10	678	49	**63**	32	**65**	29	**37**	28	**96**	78	**11**	60	**77**
3—11	425	26	**45**	15	**58**	32	**55**	24	**75**	58	**14**	39	**57**
3—12	730	53	**76**	42	**79**	17	**24**	15	**88**	70	**9**	57	**81**
Total	3235	214	**60**	144	**67**	144	**40**	131	**91**	358	**11**	275	**77**
		Plot 4. Treatment, Spray I, III. Arsenate of lead 2 lbs. per barrel.											
4—1	646	6	**27**	5	**83**	16	**73**	15	**94**	22	**3**	20	**91**
4—2	401	32	**63**	26	**81**	19	**37**	18	**95**	51	**13**	44	**86**
4—3	510	45	**55**	39	**87**	36	**44**	36	**100**	81	**16**	75	**92**
4—4	312	20	**49**	17	**85**	21	**51**	20	**95**	41	**13**	37	**90**
4—5	505	16	**42**	13	**81**	22	**58**	22	**100**	38	**7**	35	**92**
4—6	297	25	**64**	20	**80**	14	**36**	13	**93**	39	**13**	33	**85**
Total	2671	144	**53**	122	**84**	128	**47**	124	**97**	272	**10**	246	**90**

TABLE 12. *Injury by Codling Moth in the Orchard of Gilman Woodman, Durham, N. H. in 1908.*

Tree.	Total Apples*	FIRST BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	SECOND BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	TOTAL Total Wormy	Per cent.	Side Wormy	Per cent.
Plot C. No Treatment.													
C—1	564	257	**56**	99	**38**	198	**44**	164	**82**	455	**81**	263	**57**
C—3	102	44	**100**	20	**45**	0	**0**	0	**0**	44	**43**	20	**45**
C—4	863	391	**49**	141	**36**	399	**51**	323	**81**	790	**91**	464	**59**
C—5	3779	2032	**68**	359	**13**	961	**32**	520	**54**	3000	**79**	879	**29**
C—A	1200	260	**49**	102	**39**	271	**51**	136	**50**	531	**44**	238	**45**
C—B	1305	420	**56**	170	**40**	327	**44**	175	**53**	747	**57**	345	**46**
Total	7813	3704	**64**	891	**24**	2173	**36**	1318	**61**	5877	**75**	2209	**37**
Plot B. Treatment, Sprays I, III. 2 lbs. arsenate of lead per barrel.													
B—1	6299	55	**7**	32	**58**	730	**93**	505	**69**	785	**12**	537	**69**
B—2	4218	25	**6**	16	**64**	399	**94**	283	**71**	424	**10**	299	**70**
B—3	2300	58	**34**	49	**84**	112	**66**	60	**53**	170	**7**	109	**64**
Total	12817	138	**10**	97	**70**	1241	**90**	748	**60**	1379	**11**	845	**61**
Plot 2. Treatment, Spray I with atomizer. 2 lbs. arsenate of lead.													
2—7	3009	56	**11**	22	**39**	464	**89**	254	**55**	510	**17**	276	**54**
2—8	1763	31	**10**	14	**45**	268	**89**	174	**65**	299	**17**	188	**63**
2—9	692	20	**23**	14	**70**	68	**77**	40	**59**	88	**13**	54	**61**
Total	5464	107	**12**	50	**47**	790	**88**	468	**59**	897	**16**	518	**58**

* Dropped and picked.

TABLE 12.—*Concluded.*

Plot 3. Treatment, Spray I, drenched. 2 lbs. arsenate of lead.

Tree.	Total Apples*	FIRST BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	SECOND BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	TOTAL Total Wormy	Per cent.	Side Wormy	Per cent.
3—10	.3452	13	25	4	31	39	75	38	97	52	1.5	42	81
3—12	2331	1	1.6	1	100	59	98	57	97	60	2.5	58	97
3—13	1967	5	8	5	100	59	92	55	93	64	3.2	60	94
3—14	1402	3	6	3	100	45	94	35	78	48	3.3	38	79
3—15	2327	8	10	6	75	71	90	60	84	79	3.3	66	83
Total	11482	30	10	19	63	273	90	245	90	303	2.6	264	87

Plot 4. Treatment, Spray III. 2 lbs. arsenate of lead.

Tree.	Total Apples*	FIRST BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	SECOND BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	TOTAL Total Wormy	Per cent.	Side Wormy	Per cent.
4—16	1080	29	10	17	59	249	90	63	25	278	16	79	28
4—17	552	31	18	23	74	141	82	47	33	172	31	70	41
4—18	1821	37	20	25	67	145	80	95	65	182	10	120	66
4—19	1171	21	15	12	57	117	85	48	41	138	12	60	43
4—20	811	37	25	24	65	104	75	55	53	141	17	79	56
Total	5435	155	17	101	65	756	83	307	41	913	17	408	45

Plot 1. Treatment, Spray I, mist. 2 lbs. arsenate of lead.

1—1	2989	25	11	16	64	197	89	162	82	222	7	178	80
1—2	2575	9	8	7	78	96	92	86	89	107	4	93	87
1—3	2701	14	11	10	71	144	89	113	78	126	5	123	98
1—4	2738	6	4	6	100	126	95	111	88	132	5	117	89
1—5	431	5	12	2	40	38	88	25	66	43	10	27	63
1—6	2857	20	11	18	90	168	89	121	73	188	6	139	74
Total	14291	79	10	59	75	769	90	618	80	816	6	677	83

TABLE 13. *Injury by the Codling Moth in the Orchard of Albert DeMerritt, Durham, N. H. in 1908.*

Plot C. No Treatment.

		FIRST BROOD				SECOND BROOD				TOTAL			
Tree.	Total Apples*	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
C1	1044	552	75	219	40	183	25	148	81	735	70	367	50
C2	433	209	75	91	43	70	25	60	86	279	64	151	54
C3	557	98	47	52	53	109	53	76	70	207	37	128	61
C4	382	57	33	33	58	84	67	43	51	141	37	76	54
C5	1020	93	24	49	53	288	76	161	56	381	37	210	55
C6	135	46	73	23	50	17	27	13	76	63	46	36	57
Total	3552	1055	58	467	45	751	42	501	67	1806	51	968	54

* Dropped and picked.

TABLE 13.—*Concluded.*

Plot B. Treatment, Sprays I, III. 2 lbs. arsenate of lead per barrel.

		FIRST BROOD				SECOND BROOD				TOTAL			
Tree.	Total Apples*	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.	Total Wormy	Per cent.	Side Wormy	Per cent.
B1	1729	41	**58**	7	**17**	30	**42**	20	**67**	71	**5**	27	**38**
B2	1369	23	**47**	11	**43**	26	**53**	14	**54**	49	**3.5**	25	**51**
B3	900	15	**33**	3	**20**	31	**67**	24	**77**	46	**5**	27	**59**
B4	745	25	**37**	8	**32**	42	**63**	28	**67**	67	**9**	36	**54**
B5	680	27	**47**	7	**26**	30	**52**	18	**60**	57	**8**	25	**44**
Total	5423	131	**62**	36	**27**	155	**38**	104	**87**	290	**5.3**	140	**48**
				Plot 1. Treatment. Same as Plot B.									
1—1	1280	20	**27**	15	**75**	53	**73**	39	**73**	73	**5.7**	54	**74**
1—2	1330	134	**74**	57	**42**	46	**26**	36	**78**	180	**14**	93	**68**
1—3	239	22	**76**	10	**45**	8	**24**	7	**100**	29	**12**	17	**50**
1—4	320	17	**63**	9	**53**	10	**37**	9	**90**	27	**8.4**	18	**67**
1—5	156	8	**61**	5	**62**	5	**39**	4	**80**	13	**8.3**	9	**69**
Total	3325	201	**62**	96	**48**	121	**38**	95	**78**	322	**9.6**	191	**59**

Plot 2. Treatment, Spray II. 2 lbs. arsenate of lead per barrel.

2—1	457	13	**36**	4	**31**	23	**64**	11	**48**	36	**7.8**	15	**42**
2—2	176	20	**46**	10	**50**	23	**53**	13	**56**	43	**24**	23	**53**
2—3	137	18	**67**	11	**61**	9	**33**	6	**67**	27	**20**	17	**63**
2—4	780	61	**49**	29	**47**	63	**51**	32	**51**	125	**16**	61	**49**
2—5	515	27	**52**	16	**59**	25	**48**	13	**52**	52	**10**	29	**56**
Total	2065	139	**49**	70	**54**	143	**51**	75	**52**	282	**13.7**	145	**51**

Plot 3. Treatment, Spray III. 2 lbs. arsenate of lead per barrel.

3—1	681	85	**53**	41	**48**	75	**47**	37	**49**	160	**11**	78	**49**
3—2	356	21	**52**	17	**81**	28	**48**	14	**50**	59	**7.8**	31	**52**
3—3	420	17	**24**	5	**29**	53	**76**	32	**60**	70	**13**	37	**53**
3—4	580	56	**53**	27	**48**	49	**47**	27	**55**	105	**8.4**	54	**51**
3—5	412	12	**20**	2	**17**	47	**80**	24	**51**	59	**11**	26	**44**
3—6	800	29	**29**	18	**62**	72	**71**	46	**64**	101	**9**	64	**63**
Total	3249	230	**41**	110	**47**	324	**59**	180	**55**	554	**17**	290	**52**

* Dropped and picked.

TABLE 14. *Injury by the Codling Moth in the Packer's Falls Orchard, Durham, N. H. in 1908.*

Plot C. No Treatment.

Tree.	Total Apples	FIRST BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	SECOND BROOD Total Wormy	Per cent.	Side Wormy	Per cent.	TOTAL Total Wormy	Per cent.	Side Wormy	Per cent.
C—1	107	60	**87**	41	**68**	9	**13**	1	**11**	69	**64**	42	**61**
C—2	111	25	**69**	17	**68**	11	**31**	2	**18**	36	**32**	19	**53**
C—3	98	32	**69**	17	**53**	14	**30**	2	**14**	46	**47**	19	**41**
C—4	36	12	**63**	9	**75**	7	**37**	2	**28**	19	**53**	11	**58**
C—5	113	59	**70**	31	**52**	25	**30**	7	**28**	84	**74**	38	**45**
Total	465	188	**74**	115	**61**	66	**26**	14	**25**	254	**55**	129	**51**
Plot 1. Treatment, Spray I, drenched. 2 lbs. arsenate of lead.													
1—1	336	12	**57**	8	**67**	9	**43**	0	**0**	21	**6**	8	**38**
1—2	287	25	**48**	12	**48**	27	**52**	3	**11**	52	**18**	15	**29**
1—3	274	22	**69**	14	**63**	10	**31**	1	**10**	32	**12**	15	**47**
1—4	170	10	**43**	7	**70**	13	**57**	2	**15**	23	**13**	9	**39**
1—5	348	25	**64**	18	**72**	14	**36**	0	**0**	39	**11**	18	**46**
Total	1415	94	**56**	59	**63**	73	**44**	6	**8.2**	167	**12**	65	**39**

Plot 2. Treatment, Spray I, mist. 2 lbs. arsenate of lead per barrel.

2—1	104	13	**48**	12	**92**	14	**52**	60	**71**	27	**26**	22	**82**
2—2	117	11	**46**	9	**82**	13	**54**	8	**61**	24	**20**	17	**71**
2—3	136	10	**37**	10	**100**	17	**63**	0	**0**	27	**20**	10	**37**
2—4	99	7	**39**	5	**71**	11	**61**	3	**27**	14	**18**	8	**44**
2—5	57	2	**14**	1	**50**	12	**86**	3	**25**	14	**24**	4	**28**
Total	502	48	**39**	37	**86**	67	**61**	24	**36**	110	**22**	61	**55**

Plot 3. Treatment, Spray I, 2 lbs. arsenate of lead and Spray III, 10 lbs. per barrel.

3—1	97	0	**0**	0	**0**	6	**100**	0	**0**	6	**6.1**	0	**0**
3—2	56	3	**60**	3	**100**	2	**40**	0	**0**	5	**9**	3	**60**
3—3	204	15	**60**	11	**73**	10	**40**	0	**0**	25	**12**	11	**44**
3—4	205	18	**46**	12	**67**	21	**54**	2	**9.5**	39	**19**	14	**36**
3—5	186	17	**63**	12	**70**	10	**38**	2	**20**	27	**14**	14	**52**
Total	748	53	**52**	38	**72**	49	**48**	4	**19**	102	**14**	42	**41**

Plot 4. Treatment, Sprays I, III and V, 2 lbs. arsenate of lead.

4—1	321	17	**46**	13	**76**	20	**54**	3	**15**	37	**11**	16	**43**
4—2	122	11	**73**	8	**73**	4	**27**	1	**25**	15	**12**	9	**60**
4—3	106	16	**53**	11	**69**	14	**47**	1	**7**	30	**28**	12	**40**
4—4	203	14	**54**	9	**64**	12	**46**	1	**8**	26	**13**	10	**38**
4—5	407	33	**48**	18	**54**	35	**51**	5	**14**	68	**17**	23	**34**
Total	1159	91	**52**	61	**67**	85	**48**	11	**13**	176	**15**	72	**41**

Table 18 brings out the effect of the spraying in 1906 and 1907 on the amount of fruit which dropped and the worminess of the picked fruit.

In 1908 the apples injured by the first brood were picked off, so that no correct figures of the relation of dropped to picked fruit can be given. Experience has shown, however, that an almost negligible per cent. of the picked fruit is injured by the first brood of larvae, practically all being due to the second brood.

In 1908 all plots in the four orchards averaged 11 per cent. wormy for the entire season. 33 per cent. of this worminess was due to the second brood, so that not over 3 2-3 per cent. of the total crop could have been wormy picked fruit and an average of not over 5 per cent., and, on some plots only 2 or 3 per cent. of the picked fruit could be wormy.

A study of the figures shows that in most cases the value of the most efficient sprays was due to their reducing the amount of wormy windfalls, or, in other words, preventing worminess so that the fruit remained on the tree. On the unsprayed trees an average of 26 per cent. of the total fruit dropped as wormy, and 15.7 per cent. was wormy when picked.

In the four orchards sprayed in 1908, considering only the fruit which actually did drop and not including the wormy fruit picked from the trees—which would not materially affect the figures, 28 per cent. of the total fruit was wormy drops on the unsprayed trees and 5 per cent. on the sprayed trees.

An average of all the sprayed plots in table 18, shows that of the total crop of fruit on any tree, 4.7 per cent. drops as wormy and 4.1 per cent. is wormy picked. Thus, the averages for 1906 and 1907 compare very closely with those for 1908 with diverse conditions.

Subtracting the percentage which drops plus the percentage which is wormy when picked, from 100, gives the percentage of the total crop which is picked free from worms, which is the essential matter for the fruit grower. On the unsprayed plots the picked fruit free from worms is found to average only 43 per cent. of the total crop, while on all the sprayed plots it averages 70 per cent., a difference of 27 per cent. of the total crop. Thus a gain of about one-fourth of the crop seems to be a fair average of the actual benefit to be derived from spraying, if we base our estimates upon the total fruit borne by the tree. This would mean that on a sprayed tree which picked three bar-

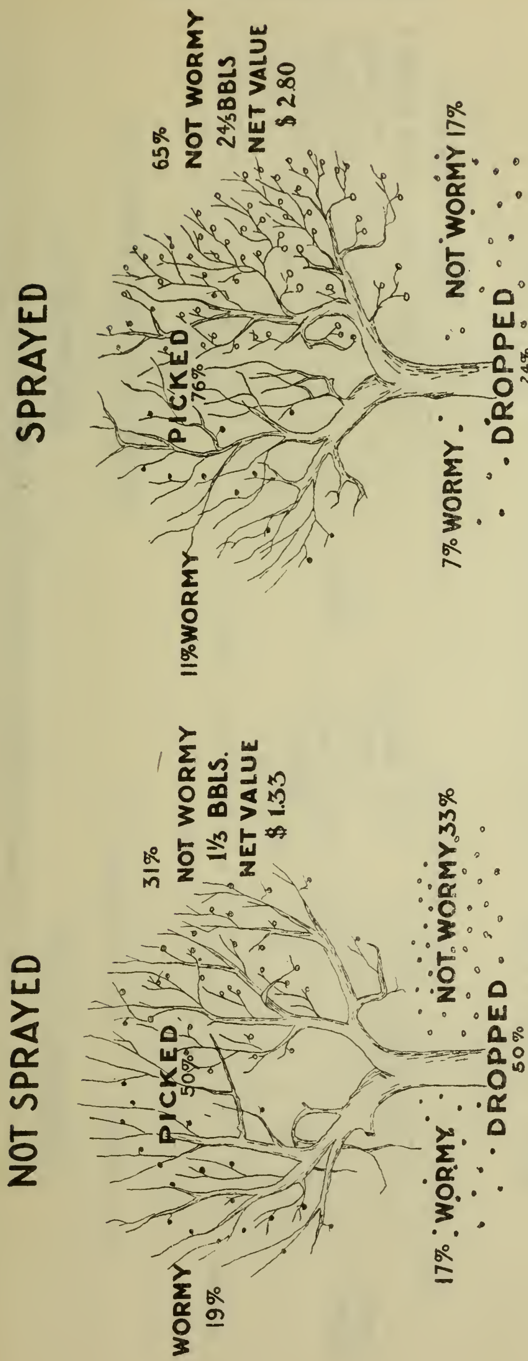


FIG. 35.—Result of spraying at Walpole, N. H., in 1906.

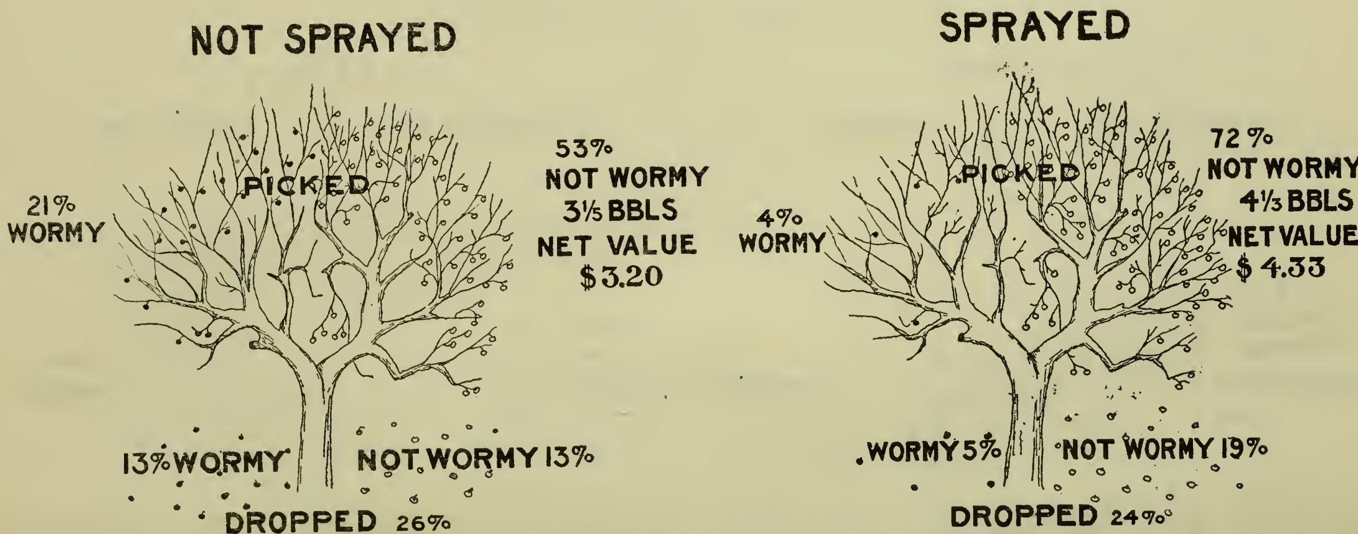


FIG. 36.—Result of spraying at Hancock, N. H., in 1906.

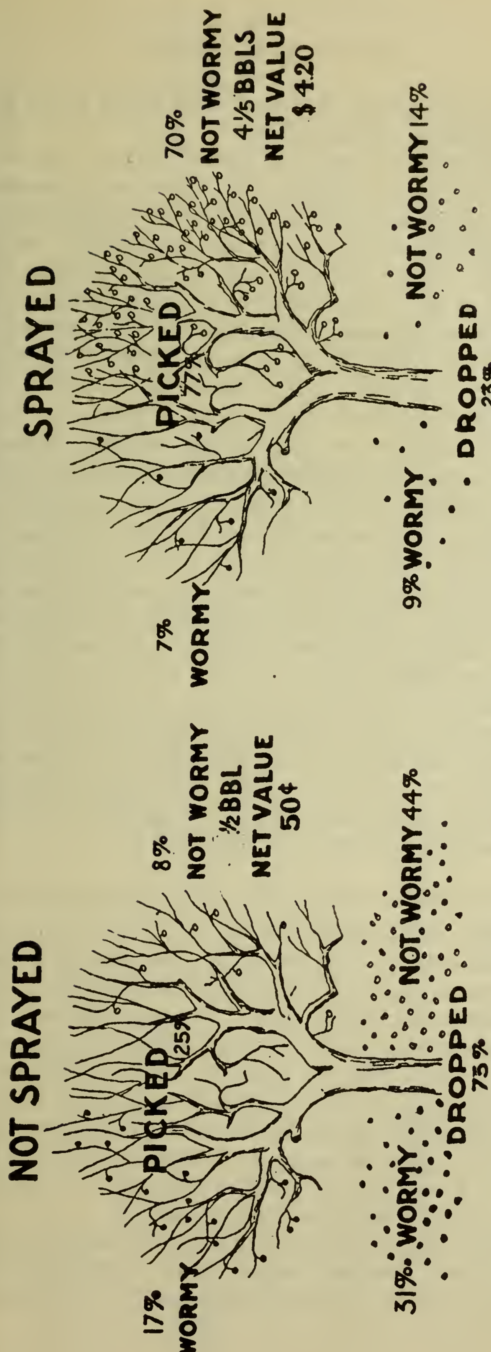


FIG. 37.—Result of spraying at Greenland, N. H., in 1906.

rels of fruit, one barrel of perfect fruit worth $1 to $1.25 net, had been gained by the spraying.

If the difference in amount of perfect picked fruit was based on the picked fruit only, leaving the drops out of consideration, the benefit would appear to be only about three-fourths of that shown above, but only by taking the dropped fruit into account can a correct estimate of the value of the spraying be made. When there is an unusual amount of worminess and the best spraying, the benefit due to spraying will often amount to half of the total fruit borne by the tree, as is shown by some of the plots in table 18, which in the case of a tree with the same amount of fruit as cited above, would amount to 2 barrels instead of one out of three picked being saved by spraying. But under average New Hampshire conditions it seems a fair estimate that about one-fourth of the total fruit, or one-third of the fruit actually picked is saved as perfect fruit, by spraying. This is shown graphically in Fig. 38. Such a statement of the benefit derived from spraying is not as striking as to say that but one apple in one hundred of those picked was wormy, but the former statement more clearly states the facts, and only one in a hundred of the picked apples may be wormy and yet the real benefit from the spraying not be as great as on other trees where a larger proportion of the picked fruit was wormy, but on which the spraying had prevented a large drop and thus secured a much larger crop to pick. The old saying that "nothing will lie like statistics," is well exemplified in considering the benefits of spraying as often recorded and compared.

The Care of the Orchard in Relation to Codling Moth Control.

The injury by the codling moth in the neglected orchard is always noticeably more severe than in one which has been given reasonably good care as regards the destruction of windfalls, pruning and scraping the trees. Although this is a matter ot general observation, in 1906 we made definite records at Durham. mine the difference in the injury in two orchards at Durham. One of these had been given practically no care for several years, and its condition is shown by the fallen limbs and the ground covered with apples as shown in Figure 39, while in the other the trees had been scraped every year, hogs had been pastured, and the remaining drops had been picked up.

The record of the neglected orchard is shown in Table 19, which does not, however, include all the drops, as the dropped fruit was not picked up until September 15. If the entire drop

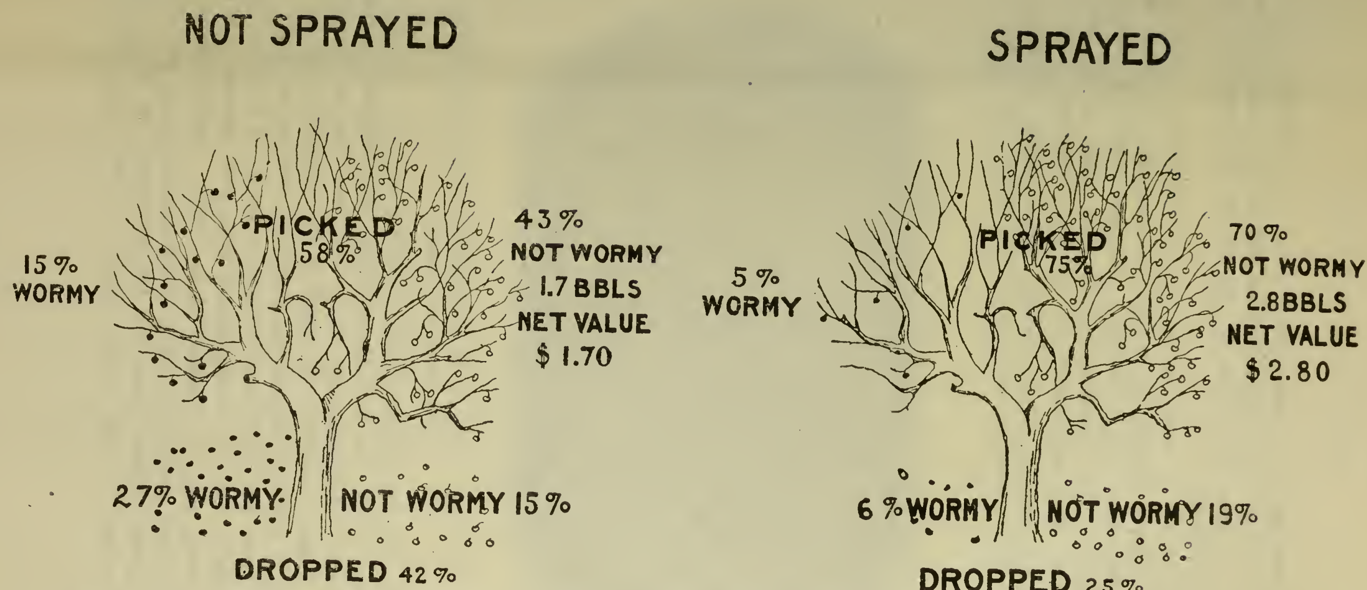


FIG. 38. Average results of spraying in nine New Hampshire orchards in 1906, 1907, and 1908, showing the proportion of fruit which drops and is picked and the proportion which is wormy and free from worms on sprayed and unsprayed trees. The profit shown is based on a crop of three barrels picked fruit on the sprayed trees.

had been secured it would, undoubtedly, have formed 50 per cent. of the total crop. The orchard which was cared for as described, is given in Tables 15 and 18 as the check plot of DeMeritt's orchard.

Considering 50 per cent. of the crop as dropping in the uncared-for orchard instead of 43 per cent. as given in Table 19, we find the following differences. In the neglected orchard three-fourths of the windfalls were wormy, while in the other only slightly over one-fourth (27 per cent.) dropped, and but half of it was wormy. Of the picked fruit one-sixth was wormy in the neglected orchard, while only one-ninth was wormy in

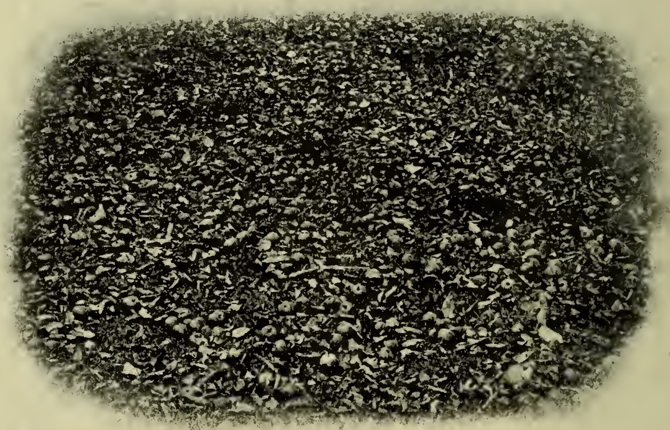


FIG. 39.—The ground covered with the droppings of the whole summer in the neglected orchard.

the other, but the wormy picked fruit formed 8 per cent. of the total crop of the tree in both cases. In the neglected orchard 42 per cent. of the total crop was picked free from worms, making two barrels worth $2 net, while in the orchard cared for, 65 per cent. of the fruit was picked free from worms, making 3 1-4 barrels, worth $3.25 net, and showing a benefit of $1.25 per tree at but slight cost for scraping the trees and picking up the drops, which pay for themselves in cider. Altogether there were but about one-half as many wormy apples during the whole season in the orchard cared for (21 per cent.), as in the neglected orchard (40 per cent.). This is shown graphically in Fig. 40.

Table 15. Summary of Spraying Experiments Against Codling Moth at Durham in 1906 and at Deerfield in 1907.

FIRST BROOD.

Plot	Treatment	No. of Trees	No. Apples per Tree	Total: Per cent of Total Fruit — Per cent	Total: Per cent of Total Fruit — Per cent Benefit	Total: Per cent of Total Wormy	Total: Benefit as "Total Per cent Benefit."	Total: September Drops. Per cent of Total Wormy
C	A. De Meritt's None	6	2415	6.7		32.7[2]	......	24.3[5]
11-15	1. 1 lb. A. L.+Bx	5	1935	5.4	20	35.2	6.4	24
51-55	1, II, 1 lb. A. L.+Bx	5	2927	5.5	17	27	5.5	14
41-45	1, II, 2 lb. A. L.+Bx	5	2706	3.2	52	27	16.0	16.
46-50	1, III, 1 lb. A. L.+Bx	5	2542	3.4	49	22	15.0	40.
16-20	1, II, V, 1 lb. A. L.+Bx	5	1790	6.4	5	35.	1.6	20
26-30	1, II, K. L. B. P. lb.	5	2082	3.8	43	31	11.	15
21-25	1, III, K. L. B. P. lb.	5	1563	4.2	37	30.	12.1	15
31-35	1, II, F. G. lb.+Bx	5	2476	3.3	51	26.	16.0	9
36-40	1, II, F. G. lb.+Bx	5	2345	2.5	62	22	20.2	12
C	Arthur Laird's None	8	411	13.5	...	70.	.	.
A	1, II, 2 lb. A. L.+Lenox Bx.	5	1304	2.2		67	.	
B	1, II, 2 lb. A. L.+Leggett's Dry Bx	1	1129	1.4		57.3	...	
C	1, II, 2 lb. A. L.+Lion Bx	5	535	2.9	...	67.2		
D	1, II, 2 lb. A. L.+1.1 Bx	5	650	1.3		73		
E	1, II, Pyrox 5 lb.	6	1962	3.3	.....	76.8	....	
F	1, II+2.4 Bx	6	2167	1.4	....	47.6		
Average	1, II, 2 lb. A. L.+Bx	33	1351	1.85	86	66.1	61.6	
H	J. Smith's None	5	515	10.0		89.0	...	
16	1, 2 lb. A. L.+2.4 Bx.	6	1790	1.4		83.5	...	
14	1, II, 2 lb. A. L.+1.4 Bx.	5	1365	1.1	...	80.9	...	
Average	....	11	1572	1.3	88	79	61.	...

FIRST BROOD (continued).

Plot	Treatment	Entered Calyx: Per cent of First Brood — Per cent	Per cent Benefit	Entered Calyx: Per cent of Total Fruit — Per cent	Per cent Benefit	Entered Calyx: Per cent of Total Wormy	Entered Calyx: Benefit as "Total Per cent Benefit."	Entered Side: Per cent of First Brood — Per cent	Per cent Benefit	Entered Side: Per cent of Total Fruit — Per cent	Per cent Benefit	Entered Side: Per cent of Total Wormy	Entered Side: Benefit as "Total Per cent Benefit."
C	A. De Meritt's None	77[1].		5.1		25[2].	......	23[2].	......	1.6	......	7.7[2]	......
11-15	1. 1 lb. A. L.+Bx	65.4	15	3.5	31	22.8	7.7	34.6		1.8	....	12.4	...
51-55	1, II, 1 lb. A. L.+Bx	51	33	2.8	45	13.7	11.2	49		2.7	......	13.3	
41-45	1, II, 2 lb. A. L.+Bx	60	22	1.9	62	15	15.5	40	......	1.2	25	10.	1.9
46-50	1, III, 1 lb. A. L.+Bx	58.	24	1.9	62	12.7	15.5	42	..	1.5	6	9.3	.46
16-20	1, II, V, 1 lb. A. L.+Bx	58.	24	3.7	27	20.3	6.7	42	...	2.7	....	14.7	.....
26-30	1, II, K. L. B. P. lb.	57	26	2.4	59	17.6	11.7	43		1.7	......	13.1	
21-25	1, III, K. L. B. P. lb.	57	26	2.4	53	20.5	13.2	43	....	1.8	.....	15.5	....
31-35	1, II, F. G. lb.+Bx	60	10	2.27	55	17.9	13.7	41.	....	1.03	35	8.4	2.7
36-40	1, II, F. G. lb.+Bx	61.	22	1.5	70	13.2	17.5	40.	......	1	37	8.8	2.8
C	Arthur Laird's None	65.1		8.5	...	43.5	...	31.9		5.	......	24.5	
A	1, II, 2 lb. A. L.+Lenox Bx.	42.5	35	1.1	....	32.5		57.5	...	1.1		34.5	20.3
B	1, II, 2 lb. A. L.+Leggett's Dry Bx	37.3	40	.52		31.7		62.1		.88		35.6	
C	1, II, 2 lb. A. L.+Lion Bx	53.7	17	1.56	.....	38.1	...	46.3		1.54	....	31.1	.....
D	1, II, 2 lb. A. L.+1.1 Bx	58.4	10	1.2		42.1	.	41.9	...	.79	......	30.6	....
E	1, II, Pyrox 5 lb.	31.5	52	.51	....	15.7		68.5		.79	....	34.1	......
F	1, II+2.4 Bx	20.2	53	.41		13.9		70.8	....	.99		33.7	....
Average	1, II, 2 lb. A. L.+Bx	48.	26	.88	90	31.7	10.9	52		.97	80	34.4	.....
H	J. Smith's None	75.	..	8.		67.4	......	25.	...	2.6	. .	22.5	.....
16	1, 2 lb. A. L.+2.4 Bx.	48.7	34	1.7		43.1		51.3		1.7	...	47.4	....
14	1, II, 2 lb. A. L.+1.4 Bx.	47.7	35	1.5		48.5		52.3		1.6		20.8	....
Average	....	48.2	31	1.6	80	39	53.	51.8	.	1.7	31	40.	8.7

FIRST BROOD (continued). TOTAL.

Plot	Treatment	Per cent of Total Fruit — Per cent	Per cent Benefit	Per cent of Total Wormy	Benefit as "Total Per cent Benefit."	Direct Benefit: Per cent Benefit	Direct Benefit: Per cent of Possible Benefit	Direct Benefit: Benefit as "Total Per cent Benefit"
C	A. De Meritt's None	11.3[1]	.	53.4	......			
11-15	1. 1 lb. A. L.+Bx	7.2	36	39.4	19.	16	20	8.4
51-55	1, II, 1 lb. A. L.+Bx	11.2	1	59.	.5			
41-45	1, II, 2 lb. A. L.+Bx	7.1	37	59.	19.6	..		
46-50	1, III, 1 lb. A. L.+Bx	9.9	12	68	6.3	....		
16-20	1, II, V, 1 lb. A. L.+Bx	7.8	31	45.	16.1	26	27	13.7
26-30	1, II, K. L. B. P. lb.	6.6	11	54	21.7	...		
21-25	1, III, K. L. B. P. lb.	5.3	53	40.	27.	16	27	8.4
31-35	1, II, F. G. lb.+Bx	8.2	27	65.	11.3	......	....	
36-40	1, II, F. G. lb.+Bx	7.4	34	66	18.			
C	Arthur Laird's None	5.8		30.		...		
A	1, II, 2 lb. A. L.+Lenox Bx.	1.1	......	33.		.		
B	1, II, 2 lb. A. L.+Leggett's Dry Bx	1.0	....	42.7				
C	1, II, 2 lb. A. L.+Lion Bx	1.4	....	32.8				
D	1, II, 2 lb. A. L.+1.1 Bx	.7	....	27.	...			
E	1, II, Pyrox 5 lb.	1.3	....	50.2	...			
F	1, II+2.4 Bx	1.5	......	52.4	.....	..		
Average	1, II, 2 lb. A. L.+Bx	1.16	80	33.9	25.			
H	J. Smith's None	1.2	..	10.1				
16	1, 2 lb. A. L.+2.4 Bx.	.5	......	11.5	...			
14	1, II, 2 lb. A. L.+1.4 Bx.	1.4		30.7				
Average	....	.95	20	21.	2.			

SECOND BROOD.

Plot	Treatment	Entered Calyx: Per cent of Second Brood — Per cent	Per cent Benefit	Per cent of Total Fruit — Per cent	Per cent Benefit	Per cent of Total Wormy	Benefit as "Total Per cent Benefit."	Direct Benefit: Per cent Benefit	Direct Benefit: Per cent of Possible Benefit	Direct Benefit: Benefit as "Total Per cent Benefit."
C	A. De Meritt's None	78.5[3]	..	8.8		11.6				
11-15	1. 1 lb. A. L.+Bx	77.1	1	5.57	37	30.3	15.3	17	21	8.7
51-55	1, II, 1 lb. A. L.+Bx	79	10	7.7	12	41.3	1.9	....		......
41-45	1, II, 2 lb. A. L.+Bx	61	21	4.3	51	35.9	21.2	..	.	..
46-50	1, III, 1 lb. A. L.+Bx	60	22	5.9	33	40.8	13.7	......	......	
16-20	1, II, V, 1 lb. A. L.+Bx	72.	8	5.6	37	32.4	15.3	32	33	13.3
26-30	1, II, K. L. B. P. lb.	68	13	4.4	50	36.7	20.5	7	12	2.8
21-25	1, III, K. L. B. P. lb.	52	33	2.7	69	25.4	28.7	32	50	13.3
31-35	1, II, F. G. lb.+Bx	63	19	5.1	42	40.9	17.4	......	. .	
36-40	1, II, F. G. lb.+Bx	70	10	5.1	42	46.2	17.4	.	.	...
C	Arthur Laird's None	21.6		1.1		7.3		....	....	....
A	1, II, 2 lb. A. L.+Lenox Bx.	33.	..	.02	.	3.3		......		
B	1, II, 2 lb. A. L.+Leggett's Dry Bx	16.4		.12		7				
C	1, II, 2 lb. A. L.+Lion Bx	20		.3		6.5		..	...	
D	1, II, 2 lb. A. L.+1.1 Bx	4.1		.03		1.2				
E	1, II, Pyrox 5 lb.	10		1	..	5.1				
F	1, II+2.4 Bx	11.5		2	.	5.8				
Average	1, II, 2 lb. A. L.+Bx	22.7	8	13	90	7.7	64.9	.1	.8	.7
H	J. Smith's None	58.1		7.	....	5.9		...		
16	1, 2 lb. A. L.+2.4 Bx.	15.3		.01		1.76	...			
14	1, II, 2 lb. A. L.+1.4 Bx.	20.9		3		6.1				
Average	....	18.1	69	17	75	3.8	4.1			......

SECOND BROOD (continued).

Plot	Treatment	Entered Side: Per cent of Second Brood — Per cent	Per cent Benefit	Per cent of Total Fruit — Per cent	Per cent Benefit	Per cent of Total Wormy	Benefit as "Total Per cent Benefit."	Direct Effect: Per cent Benefit	Direct Effect: Per cent of Possible Benefit	Direct Effect: Benefit as "Total Per cent Benefit."
C	A. De Meritt's None	21.5[4]	......	2.5	....	11.1	.....		...	....
11-15	1. 1 lb. A. L.+Bx	22.9	......	1.6	30	9.1	1.1	16	30	2.2
51-55	1, II, 1 lb. A. L.+Bx	21.	......	1.5	..	17.7		......	....	
41-45	1, II, 2 lb. A. L.+Bx	39.	...	2.8	...	23.1		.....	....	
46-50	1, III, 1 lb. A. L.+Bx	40.	..	1	..	27.2			......	
16-20	1, II, V, 1 lb. A. L.+Bx	28		2.2	12	12.6	1.1	7	7	7
26-30	1, II, K. L. B. P. lb.	32		2.2	12	17.3	1.4	....		
21-25	1, III, K. L. B. P. lb.	48		2.6	....	23.6				
31-35	1, II, F. G. lb.+Bx	37	.	3.1	.....	24.1		.....		
36-40	1, II, F. G. lb.+Bx	30		2.3	8	19.8	.8			
C	Arthur Laird's None	75.4		4.4	......	22.7				
A	1, II, 2 lb. A. L.+Lenox Bx.	90.2		.99	......	29.7				
B	1, II, 2 lb. A. L.+Leggett's Dry Bx	81.6		.88	..	35.7				
C	1, II, 2 lb. A. L.+Lion Bx	80		1.1	....	20.3				
D	1, II, 2 lb. A. L.+1.1 Bx	95.0		.07	.....	25.8				
E	1, II, Pyrox 5 lb.	90		1.2		45.1				
F	1, II+2.4 Bx	88.5		1.3	.....	16.6				
Average	1, II, 2 lb. A. L.+Bx	87.3		1.02	77	26.2	18.8			
H	J. Smith's None	11.9		.5		1.2	...			
16	1, 2 lb. A. L.+2.4 Bx.	84.7		.46		9.71				
14	1, II, 2 lb. A. L.+1.4 Bx.	79.1		1.1		24.3				
Average	....	81.9	....	.78	....	47.2				

TOTAL.

Plot	Treatment	Calyx: Per cent of Total Fruit — Per cent	Per cent Benefit	Calyx: Per cent of Total Wormy	Calyx: Benefit as "Total Per cent Benefit"	Side: Per cent of Total Fruit — Per cent	Per cent Benefit	Side: Per cent of Total Wormy	Side: Benefit as "Total Per cent Benefit"	Total: Per cent Wormy	Total: Per cent Benefit
C	A. De Meritt's None	17.1	....	80.	..	4.		20.	......	21.2	
11-15	1. 1 lb. A. L.+Bx	14.1	16	80.	12.8	3.7	7.	20.	1.4	18.1	11
51-55	1, II, 1 lb. A. L.+Bx	13	18	75	14.1	4.7	.....	25	..	18.7	11
41-45	1, II, 2 lb. A. L.+Bx	9.	17	74	37.8	3.1	22.	26.	1.4	12.1	13.
46-50	1, III, 1 lb. A. L.+Bx	10.	11	69	32.8	4.5	.....	31.		14.5	31.
16-20	1, II, V, 1 lb. A. L.+Bx	13.1	23	72.	18.1	5		28.	..	18.1	11.
26-30	1, II, K. L. B. P. lb.	8.3	51	65.	10.8	4.3	......	35.		12.6	41.
21-25	1, III, K. L. B. P. lb.	7.4	57	69	45.0	3.	25.	31.	5.	10.7	49.
31-35	1, II, F. G. lb.+Bx	8.8	48	74	38.4	3.	25.	26.	5.	11.8	44.
36-40	1, II, F. G. lb.+Bx	8.4	51	78.	40.8	2.3	42.	22.	8.4	10.7	49.
C	Arthur Laird's None	9.9		52.8		9.1		47.2		19.1	.
A	1, II, 2 lb. A. L.+Lenox Bx.	1.12		35.8	...	2.00		64.2		3.3	
B	1, II, 2 lb. A. L.+Leggett's Dry Bx	.64		28.7		1.76		71.3		2.4	......
C	1, II, 2 lb. A. L.+Lion Bx	.07	.....	12.6	....	.94		57.4		4.4	
D	1, II, 2 lb. A. L.+1.1 Bx	1.23	.....	43.6		1.1		56.4	..	2.8	
E	1, II, Pyrox 5 lb.	.61		20.8	....	1.99		79.2		2.6	
F	1, II+2.4 Bx	.61	...	19.7		2.29		80.3		2.9	
Average	1, II, 2 lb. A. L.+Bx	.93	90	39.4	17.	1.57	83	60.6	40.	3	84
H	J. Smith's None	8.7	...	93.3	.....	3.1		26.7	..	11.8	
16	1, 2 lb. A. L.+2.4 Bx.	1.73		44.9	.	2.16		55.1		3.9	66
14	1, II, 2 lb. A. L.+1.4 Bx.	1.8		54.9	.	2.7		45.1	....	4.6	61
Average	....	1.77	79	42.8	57.	2.48	20	57.2	5.3	4.25	62

1. The per cent of wormy calyx and per cent of wormy side of first brood and figures based upon them, are the results of records of the August drops and picked fruit only. Through error the September drops were not recorded as to calyx or side worminess.

2. "Per cent of total wormy," and figures based thereon, is the per cent of the total number wormy for the whole season which are wormy by the first brood, secured by taking the drops collected Sept. 29 and the picked fruit wormy and adding to the August drops which were wormy, omitting the drops of Sept. 1 and 11 of which record as to first or second brood was not made.

3. The percentages of second brood wormy through calyx and through side are based on the picked fruit only; no records of these points having been made from the September drops.

4. The "per cent of total fruit wormy" by second brood and per cent. of total wormy by second brood are secured from the picked fruit and drops of Sept. 29, drops of Sept. 1 and 11 not having been recorded as to injury by broods.

5. "Per cent of total wormy September drops" gives the percentage of the total number of wormy fruit for the season which were in the drops of Sept. 1 and 11. These were classified as to worminess, but not as to whether wormy by first or second brood or in calyx or side. This error of records accounts for apparent discrepancies between the sums of various columns in the tables and the totals given.

Table 16. Summary of Spraying Experiments Against the Codling Moth at Durham and Pittsfield in 1907.

FIRST BROOD. — TOTAL and ENTERED CALYX.

Plot	Treatment	No. Trees	No. Apples per Tree	Total: Per cent. of Total Fruit: Per cent.	Per cent. Benefit.	Per cent of Total Wormy	Benefit as "Total Per cent. Benefit."	Per cent of Total Benefit Two Broods	Entered Calyx: Per cent. of First Brood: Per cent.	Per cent. Benefit.	Per cent. of Total Fruit: Per cent	Per cent. Benefit.	Per cent of Total Wormy.	Benefit as "Total Per cent. Benefit."	Per cent of Total Benefit Two Broods
	G. Woodman's														
C	**None**	7	5151	6.6		29			71		1 7		20		
1	I. Mist, 2lb. A 1		5193	.8	94	20	27.2	100	61	11	23	95	12 2	19	70
2	I. Drench, 2lb. A 1		3807	.8	88	5	25.5	98	73		.581	87	25 5	17 1	66
442—445	I. Atomizer, 2lb. A 1	1	4180	2 7	50	2	17.1	95	72		1 35	58	23	11 6	64
	II. 2lb. A 1.	5	2514	6	9	4	2.6	92	71		1 38	6	24 8	1 2	42
6	III, 2lb. A 1.	6	3362	1.3	25	41	7.2	92	75		1 7	21	30 7	1 2	30
439—441	III, above 2lb, A 1.		5175	1 9	71	47	20.5	86	71		1 55	71	33 5	11 2	70
446—449	III, above & below 2lb. A 1		1064	.3	54	71	15.0	16	86		.58	45	61	0	38
437—438	III, Soap+2lb. A 1.		4053	1 9	71	61	20.5	81	68	1	1 1	72	41 4	14 1	67
448	. . . . III, Bagged, 2lb. A 1.	1	3924	5 5	19	40	5.5	95	73		1 2	10	38 7	2	13
	I, III, 2lb. A 1.	2	2506	.49	92	30	20.6	100	57	19	28	94	17 1	18 8	70
A	I, III, V, 2lb. A 1.	5	3572	1.4	80	60	23.2	88	80		1 16	75	53 4	15	57
B	I, II, III, 2lb. A 1.	8	5181	.3	95	13	27.5	90	75		23	95	32 2	19	65
	W. A. Deering's														
C	**None**	5	1808	10.		18			67		6 5	. . .	32		
A	I, II, III, Bx only	3	1832	10		57			73		7 3		41 6		
	I, II, Mist A 1 + Bx	5	1950	1 5	85	60	10.8		89		1 34	80		25 6	
	I, II, Drench, A 1 + Bx	8	594	.9	91	45	13.6		77		7	89		28 4	
1	I, II, III, A 1. + Bx.	7	853	.89	91	63	14.6		62	7	.55	100		28 8	
1	I, II, III, A 1. 2 lbs.	5	1105	.5	95	56	15.6		69		.35	91	. . .	30	
N. Row 14—15	I, II, III, A 1. 2 lbs.	2	1005	3.1	69	47	33.1		73		2 1	65		20 8	
S. 9, 10, 11, 12	I, II, A 1 + Bx	35	528	1 5	85	51	10.8		58	13	.87	87		27 8	
14 15	V, 2 lbs. A 1.	8	725	3.3	67	30	32.2		47	30	1 7	71		23 0	
6, 7	I, II, P [illegible]	9	1051	.76	92	11	41.1		78		.6	80		28 1	
1, 5	I, II, III, P [illegible] lb + Bx	12	1173	1	90	57	13.2		72		.72	89		28 4	

FIRST BROOD. — ENTERED SIDE, TOTAL and DIRECT EFFECT.

Plot	Treatment	Entered Side: Per cent. of First Brood: Per cent.	Per cent. Benefit.	Per cent. of Total Fruit: Per cent.	Per cent. Benefit.	Per cent of Total Wormy.	Benefit as "Total Per cent Benefit."	Total: Per cent. of Total Fruit: Per cent.	Per cent. Benefit.	Per cent of Total Wormy.	Benefit as "Total Per cent. Benefit."	Direct Effect: Per cent. Benefit.	Per cent. of Possible Benefit.	Benefit as "Total Per cent Benefit."
C	None	29	. . . .	1 9		9		16.1		71	. . . .	. .	. .	
1	I. Mist, 2lb. A 1	29		15	92	7 8	8.2	1 5	90	80	63.9		. . . . . .	
2	I. Drench, 2lb. A 1	27	6	216	88	9 5	7.7	1 6	90	65	63.9	2	16	1.1
442—445	I. Atomizer, 2lb. A 1	28	3	75	60	9.	5.4	5 8	61	68	15.1	5	12	3 5
	II. 2lb. A 1.	27	6	1 62	15	3 2	1.35	11	31	66	22.	22	21	1.5
6	III, 2lb. A 1.	25	13	1 2	36	10 3	3.2	7	56	59	39.7	31	41	22.
439—441	III, above 2lb, A 1.	29		55	71	13 7	6.3	2 1	87	53	61.7	16	22	11.3
446—449	III, above & below 2lb. A 1	14	51	12	78	10	7.	1 2	92	28	65.3	38	57	27.
437—438	III, Soap+2lb. A 1.	22		6	68	19 6	6.1	.86	91	39	66.7	23	79	16.3
448	III, Bagged, 2lb. A 1.	21	27	1 1	12	10 3	3.7	5 3	66	51	46.8	47	58	33.3
	I, III, 2lb. A 1.	43		21	89	12 9	8.	1 1	90	70	63.0	- 2		
A	I, III, V, 2lb. A 1.	11	62	11	92	6 6	8.2	9	94	40	66.7	14	70	9.9
B	I, II, III, 2lb. A 1.	25	13	07	96	10 8	8.6	5	91	57	68.1	1	20	.7
C	None	33		3 3		16		11.		52		.		. . . . .
A	I, II, III, Bx only	27	18	2.7	18		2.8	7	36	43	18.7			
	I, II, Mist A 1 + Bx	11	66	16	95		15.2	7	94	31	18.8			
	I, II, Drench, A 1 + Bx	24	30	2	93		11.8	1 1	90	55	46.8			
1	I, II, III, A 1. + Bx.	18		34	89		11.2	5	95	37	19.6			
1	I, II, III, A 1. 2 lbs.	31	6	15	95		15.2	.4	96	44	50.1			
N. Row 14—15	I, II, III, A 1. 2 lbs.	27	18	8	75		12.	3 7	60	53	31.3			
S. 9, 10, 11, 12	I, II, A 1 + Bx	42	. . . . . .	63	80		12.8	1 3	88	49	15.7			
14 15	V, 2 lbs. A 1.	53		1 6	51		8.16	6 7	39	70	20.2			
6, 7	I, II, P [illegible]	22	11	16	95		15.2	1 06	90	59	46.8			
1, 5	I, II, III, P [illegible] lb + Bx	28	23	.28	91		11.6	1.7	81	63	43.6			

SECOND BROOD. — ENTERED CALYX.

Plot	Treatment	Per cent. of Second Brood: Per cent.	Per cent. Benefit	Per cent. of Total Fruit: Per cent	Per cent. Benefit.	Per cent. of Total Wormy.	Benefit as "Total Per cent. Benefit."	Direct Benefit: Per cent. Benefit.	Per cent. of Possible Benefit.	Benefit as "Total Per cent Benefit."
C	None	67	. . .	10.8		17.6		. . .		
1	I. Mist, 2lb. A 1	24	68	1	96	18.5	15.6	2	51	.9
2	I. Drench, 2lb. A 1	15	77	.21	98	9.7	46.6	10	83	4.7
442—445	I. Atomizer, 2lb. A 1	49	26	2 9	73	33.3	34.7	14	22	6.6
	II. 2lb. A 1.	53	20	5 83	16	54 9	21.8	37	40	17.3
6	III, 2lb. A 1.	55	18	5 9	61	32 4	30.4	39	49	18.3
439—441	III, above 2lb, A 1.	70		1 5	80	37 1	10.9	15	51	7.1
446—449	III, above & below 2lb. A 1	51	23	.62	94	14 7	44.7	40	83	18.2
437—438	III, Soap+2lb. A 1.	67	. .	.58	95	26 1	43.2	24	92	10.1
448	III, Bagged, 2lb. A 1.	70	12	1 2	70	30	33.3	51	63	21.2
	I, III, 2lb. A 1.	12	82	11	98	8 1	46.6	6	75	2.8
A	I, III, V, 2lb. A 1.	8	88	1	99	3 2	47.1	19	95	9.
B	I, II, III, 2lb. A 1.	6	91	.05	99	3 1	47.1	4	80	1.8
C	None	22		2.5		11.1				
A	I, II, III, Bx only	30		2 1	16	12 9	1.8			
	I, II, Mist A 1 + Bx	19	13	.17	91	5 8	10.7			
	I, II, Drench, A 1 + Bx	7	67	1 1	96	3 8	10.9			
1	I, II, III, A 1. + Bx.	4	81	.12	95	1 4	10.8			
1	I, II, III, A 1. 2 lbs.	25		.1	96	10 1	10.9			
N. Row 14—15	I, II, III, A 1. 2 lbs.	17	22	.7	72	11.	8.2			
S. 9, 10, 11, 12	I, II, A 1 + Bx	10	51	.2	92	4 9	10.4			
14 15	V, 2 lbs. A 1.	26		2.	20	18.	2.2			
6, 7	I, II, P [illegible]	7	68	.08	96	4 1	10.9			
1, 5	I, II, III, P [illegible] lb + Bx	17	31	.3	88	9 4	10.3			

SECOND BROOD. — ENTERED SIDE.

Plot	Treatment	Per cent. of Second Brood: Per cent	Per cent. Benefit.	Per cent. of Total Fruit: Per cent.	Per cent. Benefit.	Per cent of Total Wormy	Benefit as "Total Per cent Benefit."	Direct Effect: Per cent.	Benefit.	Per cent. of Possible Benefit.	Benefit as "Total Per cent Benefit."
C	None	33		5.3	. . . .	23.1					. .
1	I. Mist, 2lb. A 1	76		1 1	79	31 2	18.5	15			
2	I. Drench, 2lb. A 1	85		1 36	71	55 6	17.3	11			
442—445	I. Atomizer, 2lb. A 1	51		2 9	45	34 7	10.5	-11			
	II. 2lb. A 1.	45		5 17	2	31 1	.1	7			
6	III, 2lb. A 1.	45		1 1	11	26 6	9.6	+32		12	7.1
439—441	III, above 2lb, A 1.	30	9	6	80	15 0	20.8	+18		62	1.2
446—449	III, above & below 2lb. A 1	49		.28	90	11 5	20.	+36		51	8.4
437—438	III, Soap+2lb. A 1.	33		.28	94	12 9	21.0	+23		90	5.3
448	III, Bagged, 2lb. A 1.	41		2 2	58	21	13.5	+39		18	6.6
	I, III, 2lb. A 1.	41		.36	81	66 6	18.9	11			
A	I, III, V, 2lb. A 1.	92		.8	85	38 8	19.8	+5	25		
B	I, II, III, 2lb. A 1.	44		.47	91	56 6	21.2	-1			
C	None	78		8.5		40.6					
A	I, II, III, Bx only	70		4 9	12	31 1	16.9				
	I, II, Mist A 1 + Bx	81		.56	94	25 2	38.1				
	I, II, Drench, A 1 + Bx	93	1		88	51 2	35.9				
1	I, II, III, A 1. + Bx.	96		.18	93	56 6	38.8				
1	I, II, III, A 1. 2 lbs.	77		1	94	33 9	39.5				
N. Row 14—15	I, II, III, A 1. 2 lbs.	83	5	.61	11	44	26.1				
S. 9, 10, 11, 12	I, II, A 1 + Bx	90		1 1	87	41 1	35.3				
14 15	V, 2 lbs. A 1.	74	5	1 7	14	52 8	18.				. . . . . .
6, 7	I, II, P [illegible]	93		.96	89	54 9	35.9				
1, 5	I, II, III, P [illegible] lb + Bx	85		1 4	82	54 6	33.3				

TOTAL.

Plot	Treatment	Calyx: Per cent. of Total Fruit: Per cent	Per cent. Benefit	Per cent. of Total Wormy.	Benefit as "Total Per cent Benefit."	Side: Per cent. of Total Fruit: Per cent.	Per cent Benefit	Per cent. of Total Wormy.	Benefit as "Total Per cent Benefit."	Total: Per cent. Wormy	Per cent Benefit
C	None	15.5		08		7.2		32		22.7	
1	I. Mist, 2lb. A 1	.63	96	41	65.	1 25	82	63	26.	1 88	91
2	I. Drench, 2lb. A 1	82	91	18	63.9	1 57	79	59	25.2	2 4	89
442—445	I. Atomizer, 2lb. A 1	1 85	88	51	17.	3 65	19	16	15.	8.5	62
	II. 2lb. A 1.	10 21	31	59	23.1	6 79	5	11	1.6	17	25
6	III, 2lb. A 1.	7 6	51	65	31.6	1 4	10	5	12.8	12.	17
439—441	III, above 2lb, A 1.	2 85	81	71	55.	1 15	81	29	26.8	4	82
446—449	III, above & below 2lb. A 1	1 2	79	77	53.7	1	86	23	27.5	1.2	81
437—438	III, Soap+2lb. A 1.	1 88	89	18	10.5	.88	87	12	27.7	2 8	87
448	III, Bagged, 2lb. A 1.	7 1	52	63	35.	3 1	51	41	17.	10 7	52
	I, III, 2lb. A 1.	12	97	25	65.9	1 17	81	75	26.8	1 6	93
A	I, III, V, 2lb. A 1.	1.20	91	50	61.8	.91	87	41	27.7	2 2	90
B	I, II, III, 2lb. A 1.	32	98	40	66.6	51	92	60	29.1	84	96
C	None	11.2		11	. . .	11.8		56		21.	.
A	I, II, III, Bx only	9 4	. . .	55		7 6	31	45	10.	17	11
	I, II, Mist A 1 + Bx	1 48	81	67	30.9	72	93	33	53.1	2.2	90
	I, II, Drench, A 1 + Bx	.88	91	10	10.	1.7	100	10	50.	2.	90
1	I, II, III, A 1. + Bx.	.57	97	41	10.9	.81	93	59	52.1	1 1	93
1	I, II, III, A 1. 2 lbs.	.15	95	50	11.8	15	100	50	53.2	.9	95
N. Row 14—15	I, II, III, A 1. 2 lbs.	1	90	14	14.2	1 8	67	56	26.8	6 8	69
S. 9, 10, 11, 12	I, II, A 1 + Bx	98	80	35	30.1	1.82	81	65	16.9	2.8	80
14 15	V, 2 lbs. A 1.	1 2	85	32	28.8	6.8	13	68	23.4	10	52
6, 7	I, II, P [illegible]	72	92	01	10.1	1 08	91	60	50.6	1.8	91
1, 5	I, II, III, P [illegible] lb + Bx	80	90	12	30.6	1 81	81	67	16.1	2 7	86

Plot.	Treatment.	No. Trees.	No. Apples per Tree.	TOTAL. Per cent. of Total Fruit. Per cent.	Per cent. Benefit.	Per ce of To Worm
	G. Woodman's					
C	**None**	6	**1302**	**47.**	....	**64.**
B	I, III, A. L. 2 lb	3	4272	.1	**98.**	10.
1	I, Mist. A. L. 2 lb	6	2182	.5	**99.1**	9.
2	I, Atomizer, A. L. 2 lb	3	1821	1.9	**96.**	12.
3	I, Drench, A. L. 2 lb	5	2250	.2	**99.6**	10.
4	III, 2 lb., A. L	5	1355	2.8	**94.**	17.
	A. De Meritt's					
C	**None**	6	**592**	**30.**	....	**58.**
B	I, III, A. L. 2 lb	5	1084	2.4	**92.**	49.
1	I, III, A. L. 2 lb	5	680	6.2	**86.**	62.
2	II, A. L. 2 lb	5	413	6.7	**84.**	49.
3	III, A. L. 2 lb	6	541	7.	**77.**	41.
	W. Deering's		**552**			
C	**None**	8	**413**	**34.**	....	**71.**
B	I, III, A. L. 2 lb	10	788	2.4	**93.**	39.
4	I, III, A. L. 2 lb	6	412	5.4	**87.**	53.
1	I, Mist., A. L. 2 lb	5	530	9.	**73.**	70.
1 A	I, Atomizer, A. L. 2 lb	4	655	4.	**88.**	53.
2	I, Drench, A. L. 2 lb.,	5	425	4.9	**85.**	52.
3 A	III, Bagged, A. L. 2 lb	5	153	28.3	**17.**	78.
3	III, A. L. 2 lb	7	462	6.6	**80.**	60.
	Packer's Falls					
C	**None**	5	**93**	**40.4**	....	**74.**
1	I, Drench, A. L. 2 lb	5	283	6.6	**83.**	56.
2	I, Mist., A. L. 2 lb	5	100	8.6	**78.**	39.
3	I, A. L., 2 lb+III, 10 lb	5	149	7.	**82.**	52
4	I, III, V, 2 lb. A. L	5	232	7.8	**80.**	52

es.

	...IT.			TOTAL.	
	...cent. ...efit.	Per cent. of Total Fruit Perfect Picked.	Per cent. Benefit.	Per cent. Wormy.	Per cent. Benefit.
C	......	7.5	....	48.	....
C	......	6.7	....	34.	....
C	......	10.8	....	76.	....
C	......	14.	....	77.	....
1	......	62.	....	18.	62
1	......	68.	....	22.	54
2	......	71.	....	15.	69
2	......	79.	....	8.9	81
A)		70.	67	16.	66
5,	.....	....	....	....	....
9,	.....	....	....	....	....
C	....	53.5	....	34.	....
6,		76.3	49	12.	64
9,		77.5	51	9.2	73
6		77.2	50	11.	67
22		71.8	39	9.3	72
17		77.2	50	8·8	74
1		68.4	32	9.6	71

Table 18. Relative injury by the Codling Moth to dropped and picked apples.

In orchard of Wm. Weeks, Greenland, N. H. 1906.

			Dropped Fruit.						Picked Fruit.						Total.	
Trees.	Treatment.	Sprays.	Average Number Apples.	Per cent. of Total.	Per cent. Benefit.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Drops.	Per cent. Benefit.	Per cent. of Total.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Picked.	Per cent. Benefit.	Per cent. of Total Fruit Perfect Picked.	Per cent. Benefit.	Per cent. Wormy.	Per cent. Benefit.
C 3. 4, 5	**None**		**Av. 3456**	75		41	30.7		25	70.	17.5		7.5		48.	
C 3.			7000	84		30			16	67.	10.7		6.7		34.	
C 4.			1863	60		78			40	73.	29.		10.8		76.	
C 5			1507	49		80			51	73.	37.2		14.		77.	
16.	1 lb. A. L.†	I, II	6852	26		39			74	11.			62.		18.	62
19.	1 lb. A. L.	I, II	2440	22		58			78	12.			68.		22.	54
23.	1 lb. A. L.	I, II	3497	21		38			79	9.			71.		15.	69
24.	1 lb. A. L.	I, II	3961	17		30			83	4.3			79.		8.9	81
Average	1 lb. A. L.	I, II	4187	23	69	40	9.2	70	77	9.	6.9	60	70.	67	16.	66
5, 6, 7, 8.	1 lb. A. L.	I, II								3.						
9, 10, 11, 12	1 lb. A. L.	I, II								3.						

In orchard of C. E. L. Hayward, Hancock, N. H. 1906.

C 1 to 5	**None**		**Av. 3648**	26		50	13.		74	28.	20.5		53.5		34.	
6, 7, 8.	*1 lb. A. L.	I, II	4478	18	30	37	6.6	65	82	7.	5.7	71	76.3	49	12.	64
9, 10.	Home made A. L.	I.	3438	19	27	29	5.5	70	81	4.4	3.5	83	77.5	51	9.2	73
6 to 10	Home made A. L.	I.	3165	18	30	33	5.9	70	82	5.9	4.8	76	77.2	50	11.	67
22 to 25	Disparene	I, II	4189	24	8	20	4.8	67	76	5.6	4.2	81	71.8	39	9.3	72
17 to 20	*1½ lb. A. L.	I, II	3985	19	27	25	4.7	74	81	4.7	3.8	82	77.2	50	8·8	74
1 to 5, 11 to 16, and 21.	*1½ lb. A. L.	I, II	3765	28	0	21	5.8	53	72	5.	3.6	85	68.4	32	9.6	71

*All plots had 1 lb. first spray and 1½ lbs. second spray and 5:5 Bordeaux. †A. L.—Arsenate of Lead. P. G.—Paris Green. Bx.—Bordeaux mixture.

--Continued.

			TOTAL.	
t.	Per cent. of Total. Fruit Perfect Picked.	Per cent. Benefit.	Per cent. Wormy.	Per cent. Benefit.
...	....	....	....	....
...	48.	....	33.	....
	52.	8	31.	6
...	....	....	....	....
...	73.7	....	15.	....
	78.7	18	15.	0
...	....	....	....	....
..	34.7	....	30.	....
	64.4	48	18.	40
...	....	....	....	....
...	28.6	....	43.	....
	64.	49	23.	46
	66.9	53	15.	65
..	65.3	....	21.2	....
	74.	25	18.1	14
..	74.	25	18.7	11
	78.	36	12.1	43
..	75.	28	14.5	31
..	72.	19	18.1	14
	75.	28	12.6	41
	79.	39	10.7	49
	76.8	33	11.8	44
	78.8	33	10.7	49

Table 18. Relative injury by the Codling Moth to dropped and picked apples.---Continued.

In orchard of F. W. Hooper, Walpole, N. H. 1906.

Trees.	Treatment.	Sprays.	DROPPED FRUIT. Average Number Apples.	Per cent. of Total.	Per cent. Benefit.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Drops.	Per cent. Benefit.	PICKED FRUIT. Per cent. of Total.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Picked.	Per cent. Benefit.	Per cent. of Total. Fruit Perfect Picked.	Per cent. Benefit.	TOTAL. Per cent. Wormy.	Per cent. Benefit.
Mackintosh Red																
C 1, C 2	**None**		**Av. 1867**	**46**		**59**			**54**	**11.**	**5.9**		**48.**		**33.**	
1, 2, 3, 4	¼ lb. P. G. and Bx	I, II	3682	44	**4**	61			56	7.2	4.	32	52.	**8**	31.	**6**
Pewaukee																
C 3, 4, 5	**None**		**1755**	**23**		**54**			**77**	**5.6**	**4.3**		**73.7**		**15.**	
5, 6, 7, 8	¼ lb. Gr. Ars. and Bx	I, II	2662	15	**35**	57			85	7.5	6.3	**0**	78.7	**18**	15.	**0**

In orchard of H. H. Thompson, Walpole, N. H. 1906.

Trees.	Treatment.	Sprays.	Average Number Apples.	Per cent. of Total.	Per cent. Benefit.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Drops.	Per cent. Benefit.	Per cent. of Total.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Picked.	Per cent. Benefit.	Per cent. of Total. Fruit Perfect Picked.	Per cent. Benefit.	Per cent. Wormy.	Per cent. Benefit.
Baldwin																
C 4, 5, 6	**None**		**Av. 3462**	**49**		**29**	**14.2**		**51**	**32.**	**16.3**		**34.7**		**30.**	
1, 2, 3	¼ lb. P. G. and Bx	I, II	2298	27	**45**	34	7.1	**50**	73	12.	8.6	**24**	64.4	**48**	18.	**40**
R. I. Greening																
C 7, C 8	**None**		**2439**	**49**		**41**	**20.**		**51**	**44.**	**22.4**		**28.6**		**43.**	
1, 2, 3	1 lb. A. L., Bx	I, II	2049	20	**60**	35	7.	**65**	80	20.	16.	**28**	64.	**49**	23.	**46**
4, 5, 6	½ lb. P. G., Bx	I, II	2949	24	**51**	23	5.5	**73**	76	12.	9.1	**59**	66.9	**53**	15.	**65**

In orchard of Albert DeMeritt, Durham, N. H. 1906.

Trees.	Treatment.	Sprays.	Average Number Apples.	Per cent. of Total.	Per cent. Benefit.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Drops.	Per cent. Benefit.	Per cent. of Total.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Picked.	Per cent. Benefit.	Per cent. of Total. Fruit Perfect Picked.	Per cent. Benefit.	Per cent. Wormy.	Per cent. Benefit.
C 6 to 12	**None**		**Av. 2345**	**26.7**		**49.**	**13.1**		**73.3**	**10.9**	**8.**		**65.3**		**21.2**	
11 to 15	*1 lb. A. L	I	3195	20.	**24**	62.	12.4	**5**	80	7.1	5.9	**26**	74.	**25**	18.1	**14**
51 to 55	*1 lb. A. L.	I, II	2922	15.4	**48**	56.	8.6	**26**	85	12.	10.6		74.	**25**	18.7	**11**
41 to 45	*2 lbs. A. L.	I, II	2766	17.3	**35**	58.	10.	**23**	83	5.3	3.7	**53**	78.	**36**	12.1	**43**
46 to 50	*1 lb. A. L.	I, III	2542	16.	**40**	37.	6.	**54**	84	10.	8.4		75.	**28**	14.5	**31**
16 to 20	*1 lb. A. L.	I, II, V	1793	22.	**17**	49.	11.	**16**	78	7.2	8.		72.	**19**	18.1	**14**
26 to 30	†K. L. B. P. ⅓ lb.	I, II	2682	20.	**24**	40.	8.3	**36**	80	5.4	5.	**15**	75.	**28**	12.6	**41**
21 to 25	K. L. B. P. ⅓ lb.	I, III	1563	15.7	**41**	40.	6.2	**52**	84	5.5	4.3	**28**	79.	**39**	10.7	**49**
31 to 35	*⅓ lb. P. G.	I, II	2476	17.	**37**	33.	5.8	**55**	83	7.3	4.	**32**	76.8	**33**	11.8	**44**
35 to 40	*⅔ lb. P. G.	I, II	2345	16.8	**37**	38.	6.3	**52**	83	5.	4.2	**28**	78.8	**33**	10.7	**49**

*With 5:5 Bordeaux in each case. †K. L. B. P.—Kerosene-Limoid-Bordeaux-Paris Green mixture.

...es.---Continued.

	...RUIT.			TOTAL.	
	...er cent. ...enefit.	Per cent. of Total Fruit Perfect Picked.	Per cent. Benefit.	Per cent. Wormy.	Per cent. Benefit.
Pl	....	....	....	....	....
C.	....	46.	....	21.	....
A	52	36.	....	17.	19
1.	93	42.	....	2.2	90
2.	93	59.	24	2.	90
3.	90	71.	46	.8	96
B.	93	55.	16	1.8	91
3+	92	61.	27	1.4	93
13.	96	76.	55	.9	95
N.	76	47.	2	6.8	69
8,	86	65.	35	2.8	86
14.	51	69.	42	10.	52
15.	30	68.	40	11.	47
14.	39	68.	40	10.	52
6.	88	68.	40	1.8	91
7.	89	64.	33	1.8	91
6,	88	65.	35	1.8	91
5.	79	72.	48	3.1	85
4.	93	70.	44	1.7	92
4,	84	71.	46	2.7	86
C.	....	54	....	22.7	....
11-	94	79	54	1.9	91
2.	89	81	58	2.4	89
4.	74	72	39	8.5	61
5.	47	66	26	17.	22
6.	64	61	15	12.	45
39	88	79	54	4.	81
44	95	72	39	4.2	80
43	93	80	56	2.8	84
44	69	52	....	10.7	50
33	95	83	63	1.6	92
A	96	71	36	2.2	90
B.	98	92	91	.8	96

Table 18. Relative injury by the Codling Moth to dropped and picked apples.---Continued.

In the orchard of W. A. Deering, Pittsfield, N. H. 1907.

Trees.	Treatment.	Sprays	Average Number Apples.	DROPPED FRUIT. Per cent of Total.	Per cent. Benefit.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Drops.	Per cent Benefit.	PICKED FRUIT. Per cent. of Total.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Picked.	Per cent. Benefit.	Per cent. of Total Fruit Perfect Picked.	Per cent. Benefit.	TOTAL. Per cent. Wormy.	Per cent. Benefit.
Plot............	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
C............	None............	....	Av. 836	46	....	29.	13.	....	54	14.	7.56	....	46.	....	21.	....
A............	Bx. only............	I, II, III......	1103	60	....	22.	13.	....	40	9.	3.6	52	36.	....	17.	19
1............	* Al., Bx. Mist........	I, II..........	1920	57	....	3.	1.7	87	43	1.1	.5	93	42.	....	2.2	90
2............	Al., Bx. Drench	I, II..........	594	40	13	3.8	1.5	88	60	.7	.42	93	59.	24	2.	90
3............	Al., Bx............	I, II, III......	459	29	36	2.2	.7	94	71	.1	.7	90	71.	46	.8	96
B............	Al., Bx............	I, II, III......	1769	44	4	2.9	1.2	90	56	.9	.5	93	55.	16	1.8	91
3+B............	Al., Bx............	I, II, III......	833	38	17	2.7	1.	92	62	.9	.56	92	61.	27	1.4	93
13............	Al. only............	I, II, III....:	1105	24	48	2.6	.6	96	76	.4	.3	96	76.	55	.9	95
N. Row. 14, 15	Al. only............	I, II, III......	1005	49	0	10.	5.	61	51	3.5	1.8	76	47.	2	6.8	69
8, 9, 10, 11, 12	Al. Benz. Bx..........	I, II	528	34	26	5.6	1.9	86	66	1.5	1.	86	65.	35	2.8	86
14............	Al. only............	V.......	584	28	39	23.	6.4	50	72	5.2	3.7	51	69.	42	10.	52
15............	Al. and soap..........	V............	867	27	41	22.	6.	53	73	7.3	5.3	30	68.	40	11.	47
14, 15............	Al. (15 and soap)	V............	725	27	41	22.	6.1	53	73	6.4	4.6	39	68.	40	10.	52
6............	P. G., $CuPO_4$..........	I, II	1595	30	34	3.	.9	92	70	1.3	.9	88	68.	40	1.8	91
7............	†P.G., $CuPO_4$	I, II	2244	35	24	2.9	1.	92	65	1.2	.8	89	64.	33	1.8	91
6, 7............	P. G., $CuPO_4$..........	I, II	1984	33	28	2.9	.9	92	67	1.3	.9	88	65.	35	1.8	91
5............	P. G., Bx. K. L. B. P.	I, II, III......	1975	26	43	5.6	1.4	89	74	2.2	1.6	79	72.	48	3.1	85
4............	P. G., Bx,............	I, II, III......	600	29	36	4.6	1.3	89	71	.6	.4	93	70.	44	1.7	92
4, 5............	Above............	I, II, III......	1173	27	41	5.3	1.4	89	73	1.7	1.2	84	71.	46	2.7	86

*2 lbs. arsenate of lead per barrel. † ⅓ lb, Paris green per barrel; for fungicides used see text.

In the orchard of Gilman Woodman, Durham, N. H. 1907.

Trees.	Treatment.	Sprays	Average Number Apples.	DROPPED FRUIT. Per cent of Total.	Per cent. Benefit.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Drops.	Per cent Benefit.	PICKED FRUIT. Per cent. of Total.	Per cent. Wormy.	Per cent. of Total Fruit Wormy Picked.	Per cent. Benefit.	Per cent. of Total Fruit Perfect Picked.	Per cent. Benefit.	TOTAL. Per cent. Wormy.	Per cent. Benefit.
C............	None-............	....	5151	30	....	26.	8.	....	70	25.	17.5	....	54	....	22.7	....
11—16............	* Al. Mist............	I............	3193	19	36	4.2	.8	90	81	1.3	1.	94	79	54	1.9	91
2............	Al. Drench............	I............	3897	16	46	6.9	1.1	86	84	2.8	2.2	89	81	58	2.4	89
4............	Al. Atomizer	I............	3090	24	20	17.	4.	50	76	5.8	4.4	74	72	39	8.5	61
5............	Al	II............	2764	23	23	33.	7.8	2	77	12.	9.2	47	66	26	17.	22
6............	Al............	III............	3203	32	....	17.	5.6	30	68	9.1	6.2	64	61	15	12.	45
39—441............	Al. from above.......	III............	5175	18	40	10.	1.9	77	82	2.6	2.1	88	79	54	4.	81
446—447............	Al. above and below .	III............	4094	27	10	10.	2.9	63	73	1.2	.87	95	72	39	4.2	80
437—438............	Al. and soap..........	III............	4053	19	36	12.	2.3	71	81	1.4	1.1	93	80	56	2.8	84
448............	Al. bagged............	III............	3924	43	....	13.	5.8	27	57	8.4	4.8	69	52	....	10.7	50
330—332............	Al	I, III..........	2536	16	46	4.1	.65	92	84	1.1	.9	95	83	63	1.6	92
A............	Al	I, III, V......	3512	28	6	5.6	1.5	81	72	1.	.7	96	71	36	2.2	90
B............	Al	I, II, III......	5181	11	63	3.5	.5	93	89	.4	.3	98	92	91	.8	96

*2 lbs. per barrel.

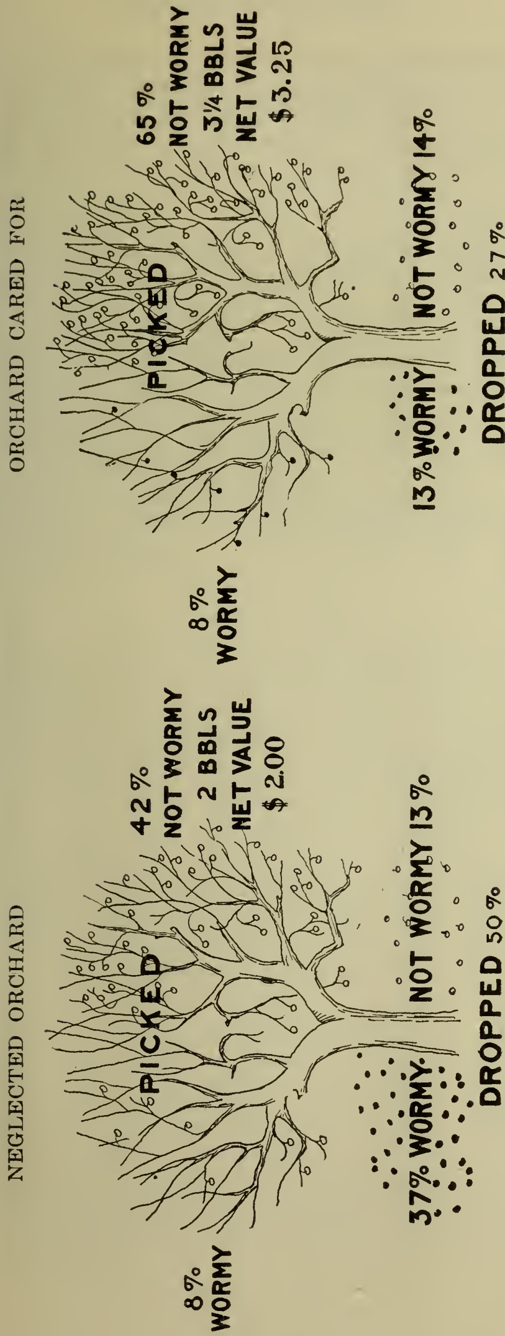


FIG. 40. The price of neglect.

It is evident that the difference in infestation may not have been due to the difference in care, but considering all the conditions in the two orchards, such as location, size of crop, etc., the comparison seems a fair one and the difference may fairly be attributed to the neglect of one and the little care given the other.

TABLE 19. *Showing injury by the Codling Moth in an orchard at Durham, N. H. in 1906 which had had poor care.*

	DROPPED				PICKED				TOTAL		
Tree.	Total.	Per cent.	Wormy.	Per cent.	Total.	Per cent.	Wormy.	Per cent.	Total.	Wormy	Per cent.
1	2215	63	1768	80	1294	37	124	10	3509	1892	54
2	1431	33	969	67	2920	67	323	11	4351	1292	29
3	833	35	576	69	1501	65	298	20	2334	874	27
4	1191	40	890	74	1747	60	304	17	2938	1194	33
5	601	42	445	74	825	58	190	44	1426	635	44
Total	6271	43	4648	74	8287	57	1239	40	14558	5887	40

THE STRIPED CUCUMBER BEETLE.

(*Diabrotica vittata* Fabr.)

T. J. HEADLEE.

HISTORY AND DISTRIBUTION.

According to Fitch[1] this insect was named *Cistela melanocephala* by Fabricus in 1871 After some renaming and shifting in systematic position, it received the present name. Shimer[2] published an account of its natural history in 1865, and the same year Fitch published another. Chittenden[4] in 1898, and later, Sirrine[5] in 1899, Garman[6] in 1901, and others at various times, have contributed to our knowledge of its habits and life history. In his discussion in 1865, Fitch gave a clear account of the measures of control he had found best, and other suggestions have since come from many sources.

According to Chittenden[7] the striped cucumber beetle occurs in practically all the states east of the Rocky Mountains and in the state of Washington.

LIFE HISTORY AND HABITS.

Hibernation. It was first thought, notably by Shimer, that this insect passed the winter in the pupal stage, but since that time opinion has changed until it has come to be generally agreed that the beetle passed the winter as an adult. Riley[8] inferred the hibernation of adults from their presence in the fields after heavy frosts, and many have confirmed his observations and noted that they appear to be driven into winter quarters by the cold. Garman[9] found a hibernating beetle December 6th with a mass of rubbish and other insects under boards, and he carried some adult beetles collected in the fall through the winter in the soil of his vivarium. In New Hampshire we found that all the pupae in our breeding cages transformed to adults before cold weather.

1. 10th Rept. on the Noxious and Other Insects of the State of N. Y., 1865, p. 438 of the Trans. of the N. Y. State Agric. Soc. for 1864.
2. Prairie Farmer, Aug. 12, 1865.
4. Bul. No. 10, n. s., Bureau of Ent., U. S. Dept. Agric., 1899, pp. 26-30. Bul. No. 19, n. s., Bureau of Ent., U. S. Dept. Agric., 1899, pp. 48-51. "Insects Injurious to Vegetables."
5. Bul. No. 158 of the N. Y. Agric. Expt. Sta., Geneva, 1898.
6. Bul. No. 91 of the Kentucky Agric. Expt. Sta., 1901, pp. 3-16.
7. Circ. No. 31, Revised edition, Bur. Ent., U. S. Dept. Agric., p. 1.
8. 2d Rept., Noxious, Beneficial and Other Insects of Mo. p. 66
9. l. c. page 4.

The date at which the beetles appear in the spring seems to vary with the season and latitude from some time in April to early June. Many writers simply make the general statement that they emerge in the early spring. Fitch[1] speaks of their appearance in New York in May. Chittenden[2] speaks of their appearing about Washington, D. C., some time in April, Smith[3] mentions them as appearing in New Jersey in May, Sirrine[4] says that in New York the date varies from April to the first of June, Garman[5] records their earliest appearance in Kentucky as April 12th, and in 1907 in New Hampshire we found them June 1st. They did not appear on cucurbits until June 24th.*

It is generally agreed that the beetles frequently emerge before the cucurbitaceous plants are above the ground, and that they feed on almost anything they can get. They have been recorded as feeding at this time on the leaves of horse chestnut and such fruit blossoms as they can find. Fitch[6] spoke of them as abundant on the leaves and blossoms of *Crataegus* and thought that they probably fed on them. We found them feed-

1. l. c., page 438.
2. Bul. No. 10, n. s., Bureau of Ent., Dept. Agric., p. 29.
3. Rept. of N. J. Agric. Expt. Sta., 1892, p. 43.
4. l. c., p. 6.
5. l. c., p. 4.
6. l. c., p. 439.

*An effort was made to secure some information concerning the hibernating habits experimentally in the fall of 1907. 200 beetles were placed in each of four large cages in which young seedlings were available for food. These cages were placed in a squash patch and beneath them wire screening was placed 3, 6, 12, and 18 inches beneath the surface, so that beetles entering the soil could not penetrate beneath these screens. In this way it was thought that we might be able to determine how deep the beetles hibernate by the number emerging in each cage the next spring. The beetles were observed as numerous in the cages until the last week of September. 25 were observed on plants in one cage on September 30. The bottoms of the cages were covered with old vines. On Oct. 10 we recorded that after several frosts practically all the beetles in the cages had disappeared. The time of entering hibernation seems to be coincident with the first frosts and does not seem to be determined by the mean temperature of the day. Another cage with a similar number of beetles was placed in a pine grove where the soil was covered with pine needles and potted plants for the beetles to feed on during the fall were introduced. The winter passed with very little snow, but unusually deep and severe freezing of the soil. Whether as a result of this or not we cannot at present state positively, but not a single beetle appeared in any of these cages in the spring of 1908. Furthermore there were very few beetles to be found on young squash and melons until late in June and then so few as to cause no appreciable damage. (E. D. Sanderson.)

ing at such times on the leaves of elm, and more abundantly on leaves and blossoms of syringa. Sirrine[1] emphasizes the fact that their appetite between the time of emergence and mating is so voracious that they will eat almost anything, but after pairing begins they refuse to eat food covered with a foreign substance. The adult insect has been recorded as feeding upon beans, peas, wild balsam apple, young leaves of horse chestnut, cotton pollen, the flowers of both cultivated and wild asters, on the spotted crane's-bill, the silks, pollen and unripe kernels of corn, the blossoms of apple, chokecherry, juneberry, cherry, and related plants, sunflowers, goldenrod, and possibly leaves and flowers of *Crataegus*.

In New Hampshire the insects were pairing when they attacked the squash and cucumber plants, and, like those observed by Sirrine[1], they refused to eat any part of the plants covered with a foreign substance, but would seek for spots that had been left untouched. From the first appearance of these plants until they began to blossom, the beetles deserted all other sorts of food, feeding on their leaves and stems, always selecting the tenderest parts within reach. At this time they tended to concentrate on the tender replants and quickly destroy them. When the flowers appeared the beetles turned their attention to them, seeming to feed mainly on the pollen. Sanderson[2] records their feeding on, and seriously injuring, the pistils in Delaware. In the fall we took them on the flowers of goldenrod and on the plants in the patch until early October, when they were found entering winter quarters. Sirrine[3] states that pairing begins about the middle of June and continues until the middle of August, and that the males will sometimes attempt to pair with the twelve-spotted species.

Oviposition. In New Hampshire the beetles were found pairing freely on June 24th, and copulation continued until about August 30th. We, also, found the males attempting to pair with the twelve-spotted beetles. Garman[4] records Jan. 18th and July 26th as the limits of oviposition in Kentucky. Sirrne[5] says that dissections show that egg-laying could begin June 20th, but that in 1898 it did not begin until July 20th, and that the

1. l. c., page 6.
2. Rept. of Agric. Expt. Sta. of Delaware, 1900, page 209.
3. l. c., pages 6-7.
4. l. c., page 6.
5. l. c., pages 7 and 8.

egg-laying period is about one month. Our observations showed the period of oviposition to be of about the same length, the first eggs in 1907, being obtained July 2nd and the last August 6th.

Fitch[6] says that the beetles drop the eggs about the plants, but does not signify whether above or below the surface of the soil. Sirrine's[7] observations led him to conclude that the beetles dropped their eggs wherever they happened to be feeding. Garman[8] says that the beetles creep into crevices alongside or near the plant to deposit their eggs, and that they are placed, as a rule, near the surface. In New Hampshire, in both field and cage, we found the eggs deposited in the surface of the soil, singly or in groups, usually within a crack or crevice, anywhere within several inches of the plant. The female beetles appeared to make a special effort to place the eggs on damp soil, but did not especially favor the place between stalk and soil. On the afternoon of July 10, 1907, it was our good fortune to observe a female beetle ovipositing in one of the cages. As the pair had been in the cage 16 days when the beetle deposited the eggs, and as they seemed well satisfied, it is reasonable to regard the following actions as very closely approaching the normal. The female was walking about on the soil and poking her head into every crevice, moving her antennae with peculiar vigor when examining such places. Apparently unable to find any place more to her liking, she stopped over a tiny crevice, and, curving the tip of her abdomen downward until it almost or quite touched the soil, remained in that position for about ten seconds, giving two downward pushes, apparently accompanied by a contraction of the abdominal walls. Later examination showed within this crevice, just barely below the general level of the soil, an oval, lemon-yellow egg. From this point she passed outward toward the rim of the pot and soon came to a deep furrow in the soil where the steel rim of the cage had formerly been inserted. She at once crawled into it and deposited two more eggs, one on the side of the furrow, near the bottom, and the other quite on the bottom. These eggs, in due time, gave forth healthy larvae. Very few facts appear to have been accumulated to show the number of eggs that a single female may produce. Dissections of 18 gravid females showed an average of 33 eggs, with

6. l. c., page 439.
7. l. c., page 7.
8. l. c., page 6.

an upper limit of 59. Five pairs, confined in breeding cages, produced an average of 88 eggs per pair.

Egg. The egg was first described by Chittenden[1] and very soon afterwards by Sirrine[2]. Few data are available on the length of the egg stage. In 1906 we attempted to determine the length of egg stage by placing freshly deposited eggs in glass tubes, the open ends of which were covered with muslin. The tubes were then sunk vertically into the moist soil so that the upper ends were even with the surface. More than 100 eggs were thus experimented with. We found this unsatisfactory because of the difficulty of making the examination and because the larvae escaped through the cloth into the soil. Such of the eggs as we were able to observe, required from eight to twelve days to hatch. The same season's work also convinced us that the eggs should have moist conditions for their development. In 1907 the freshly laid eggs were placed in a moist chamber made by sealing a glass ring, from 1-4 to 1-2 inch high, to a glass slide with paraffine and sealing over the top a cover glass carrying a hanging drop of water. The eggs were thus subjected to a saturated atmosphere and the cells were kept in almost complete darkness. Every day they were examined with hand lens and microscope and unsealed as often as eggs hatched or the drops needed replenishing. Hatched larvae were removed as soon as they appeared. The cells were exposed to air at an average mean temperature of 74 degrees F.,* and 32 eggs observed required an average of 7.7 days for hatching.

When first laid the egg has a diffused lemon-yellow color, but as development progresses, the color concentrates in the forming embryo. When fully developed the embryo extends almost completely around the egg in the long diameter. A larva which we observed cut a tennis-racquet-shaped hole near one end and crawled out.

Larva. The larval form was mentioned by both Shimer and Fitch. According to Thomas[3], Dr. Shimer gave the length of

1. l. c., p. 48.
2. l. c., p. 10.
3. Trans. Ill. Hort. Soc., Vol. XI, p. 167.

*The average mean temperature has been computed by (1) averaging the mean temperature of the days through which each egg passed before hatching, and then (2) averaging the average mean temperature of all the eggs. The number of daily mean temperatures averaged for each egg will be larger than the number of days in the stage by 1 because the temperature of both the first and last day must be considered.

the larval stage as about one month. J. B. Smith[2] says the larva matures in three weeks; Sirrine[3] expresses the opinion that it varies from one to two months according to the food supply. Garman[4] records the average length of larval life in Kentucky as 19 days. In New Hampshire, under an average mean temperature of 73 degrees F., 24 individuals spent an average of 27.1 days in that stage.

When first hatched the larva is very active and crawls rapidly about, occasionally stopping to raise one-half or more of its body from the ground and wave it back and forth. In a moist chamber the just-hatched larva will crawl about as much as two days without food, but if subjected to dry air it quickly perishes. The ability of the larvae to move through damp soil was demonstrated repeatedly in the course of this study, but when placed on it, they showed no more tendency to crawl toward the food plant than away from it, though all showed the disposition to go into the earth at the first opportunity.

According to Fitch, the larva lives in the succulent parts of the infested cucurbit, between the surface of the soil and the fibrous roots, boring out the stalk and killing it. Sometimes, according to the same author, they will be found attacking the sprouts of seeds that have been planted to take the place of the plants destroyed. Lintner[3] records an instance where seven nearly full-grown larvae were taken from the stem within a length of two inches. Most of the later investigators have contented themselves with the statement that the larval stage is passed in the soil about the roots. Sirrine[4] points out the fact that they also attack vines and fruit when these lie on damp soil, and that he has rarely found them attacking the stems of muskmelon. Neither has he been able to find them feeding on the roots. In New Hampshire we found the larvae feeding on the roots, as Fitch describes, and in some cases boring up into the stem. In our breeding cages the larvae very generally mined the stem, sometimes as high as two inches above the ground. In 1906 and 1907 the number of larvae to be found on the plants seemed very small in comparison to the number of eggs laid and the number of beetles into which they must have developed.

Pupation. According to Fitch[5], the larva when full grown, crawls away from the roots and forms a cavity in the ground

2. Rept. Agric. Expt. Sta. of N. J., 1890, p. 481
3. l. c., pages 6 and 7.
4. l. c., p. 8.
5. l. c., p. 436.

by turning itself round and round until the wall is smooth, and so hard that it will not break open from any disturbance of the surrounding earth likely to be made by hoe or plow. Garman[1] notes that the larva becomes greatly shortened before transforming. Our observations verify both of these statements, except in the particular of the resistant nature of the cells. Those with which we worked seemed to have frail walls. The cell may be broken open and, unless the larva has begun to shorten and stiffen, it will form a new one. If, however, it has greatly shortened and thickened it will make no attempt to construct a new cell, but will transform to a pupa as best it may. There is some indication that the depth at which the cell is constructed depends upon the soil moisture. In cages where the soil was moist all the way to the top, the cells were constructed within one-half inch, or even less, of the surface, but in others where the surface soil was dry, the cells were constructed in the moist soil, even when that was two and one-half inches below the surface.

Chittenden[2] determined that in August with temperature from 75 degrees to 85 degrees F. the pupal stage can be passed in seven days. Garman[1] determined the pupal stage as about 8 days. We found it necessary to break the larval cell to tell when the pupal stage began and the results were, therefore, hardly normal. Records from 10 pupæ show that an average of 13 days is required to complete this stage under an average mean temperature of 65.9 degrees F. Records of 14 individuals, which were undisturbed from formation of larval cell to adult, show that an average of 23 days was required for the insect to pass this stage under an average mean temperature of 66 degrees F.

Seasonal history. Garman[3] found that the period from hatching to adult varied from 26 to 33 days, and that the records of 10 beetles gave an average of 38.5 days. It was to be expected that the length of this part of the life cycle in New Hampshire would be greater because of the lower temperature, but the difference is so remarkably large that it will be well to submit the records on which our conclusions are based. Fourteen individuals, which were undisturbed, required an average of 54.14

1. l. c., p. 7.
2. Bul. No. 10, n. s., Bureau of Ent., U. S. Dept. of Agric., p. 29.
3. l. c., p. 7.
4. l. c., p. 9.

days to pass from hatching of egg to adult, under an average mean temperature of 69 degrees F.

TABLE I. *Records of individuals that were undisturbed by breaking of larval cell from hatching of egg to emergence of adults*

Cage No.	No. of larvae.	Date of hatching.	Date of adult. beetle emergence.	Length of period in days.
21	1	7-27-'07	9- 9-'07	44
21	1	"	9-25-'07	60
21	1	"	"	60
2	1	7-19-'07	9- 9-'07	52
6	1	7-25-'07	"	46
20	1	7-27-'07	9-13-'07	48
20	1	"	10- 1-'07	66
3	1	7-25-'07	9-18-'07	55
12	1	"	"	55
12	1	"	"	55
23	1	8- 1-'07	9-20-'07	50
23	1	"	"	50
23	1	"	9-25-'07	55
4	1	7-25-'07	"	62
	14		Average length of period, 54.14 days	

The length of period from the hatching of the egg to adult, 54.14 days, added to the average length of the egg stage, 7.7 days, gives a total of 61.8 days required to complete the life cycle, under an average mean temperature of 70 degrees F.[1] Breaking the larval cell seemed to shorten the time necessary for the insect to pass from hatching to adult. Twenty-two individuals that passed this stage under these conditions required an average of 46.8 days under an average mean temperature of 70 degrees F. The soil of the cages was kept moist but not wet. Indeed, during most of the time, a thin surface layer was kept dry and pulverized.

Most writers seem to be of the opinion that the insect has two to three broods annually. Chittenden[2] summed the matter up, in 1903, as follows: "Considering its long season and the fact that newly transformed beetles have been observed from the second week of July till the first week of October, there is comparative certainty of two generations, as generally admitted, each year in the northernmost locality inhabited by the species,

1. The average mean temperature for the whole period was determined in this case by multiplying the average mean temperature for each of the two periods considered by the number of days—1 in each period, respectively, adding the results and dividing the sum by the total number of days + 2. (See note on p. 503.)

2. Cir. No. 31, Revised edition, Bureau of Ent., U. S. Dept. of Agric., pgs. 3-4.

and it is safe to assume the existence of three generations annually from the District of Columbia southward,'' but Sirrine[1], basing his conclusion upon field observations and dissections, says, "The dissections of the females of the new brood show, also, that the reproductive organs are not developed and do not develop even as late as the middle of October. Furthermore, by the dissection it was shown that a large amount of fatty tissue is formed preparatory to hibernation. In addition to the above facts, observation in the fall showed that there was no tendency to mate during the fall. Hence, it is evident that the statement that there is more than one brood each year is wrong."

TABLE II. *Results from dissecting beetles gathered at different periods throughout the summer and early fall.*

Date of Collection.	No. of Females.	No. with well developed eggs.	Total No.	Number parasitized.	Females parasitized.
6-28-'07	8	5	28	2	1
7- 1-'07	5	3	18	1	1
7-30-'07	7	3	26	2	0
8- 5-'07	8	5	22	4	1
8- 8-'07	2	0	8	3	1
8-13-'07	3	0	12	6	3
8-14-'07	0		6	3	0
8-22-'07	3	0	21	5	1
8-31-'07	15	0	24	3	3
9- 7-'07	8	0	18	0	0
9-12-'07	8	0	14	0	0
9-18-'07	5	0	9	0	0

In 1902 Mr. A. F. Conradi, then connected with the New Hampshire station, carried on some breeding work in which he found that the adult beetles emerged in his cages from August 19th to October 2d. We introduced a copulating pair of beetles into each of twenty-two cages at dates ranging from June 26th to July 8th, 1907, and two additional cages were stocked with males and females taken from different plants, No. 23 on July 5th, and No. 24 on July 16, 1907. Squash seeds were planted every few days so that the beetles always had a supply of succulent food. Just-hatched larvae from eggs laid by beetles in the cages that have already been described, were introduced into twenty-four other cages, also kept supplied with succulent squash in the same way. Of the 48 cages, 24 gave forth beetles of the new brood. A total of 71 beetles emerged. The first came out

1. l. c., p. 9.

August 26th, the last Oct. 1st, and the majority had emerged by September 19th. The last eggs found were laid in a cage by a beetle introduced July 16th. For some days before this date we had been unable to find eggs in the field. The table shows that we have been unable to find developed eggs in the female beetles collected on and after August 8th. The average length of life cycle, 61.7 days, or even the shortest in our record, 51.7 days, is so long that the maturing of the second brood after the earliest emergence would seem impossible. Accordingly, we are driven to the conclusion that the beetle is single-brooded in that portion of its range which includes New Hampshire.

Natural Enemies.

In 1871 Shimer[1] gave an account of a dipterous parasite that he had bred from the adult beetle. It was described under the name *Tachina* (Melanosphora) *diabroticae.* Chittenden[2] records finding the dipterous parasite, *Celatoria diabroticae*, which he identifies with that found by Shimer. He also considers the form, *Celatoria crawii* Coq., reared in California from *Diabrotica soror*, as the same form. Others record the finding of similar dipterous parasites in the adult beetles. We found them thus infested. The natural enemies of this insect are totally insufficient to keep it from being seriously injurious to crops.

Injury.

According to Fitch[3], and others, the injury is largely due to the overwintered beetles eating the seed, leaves and stems of the emerging plants, sometimes nipping them off before they reach the surface of the ground, later to their consumption of the tender parts of stem, foliage, and flowers, and to their habits of attacking the fruit, and partly due to the destruction of the roots, stems, fruit, and sometimes of the just-bursting seeds, by the larvae. Sirrine[4] says that the larvae attack the stems and fruit where these come in contact with the moist soil. In New Hampshire all the types of injury described, except that by the larvæ to the fruit and vines in contact with moist soil, were observed. It has also been found by us that the feeding of the beetles on squash stems frequently results in a form of injury that makes its appearance only after the plant is well grown,

1. Amer. Nat., Vol. V, pgs. 217-220.
2. Bul. No. 10, Div. of Ent., U. S. Dept. of Agric., pgs. 29-30.
3. l. c.
4. l. c.

If the beetle fails to gnaw entirely through the stem, the wound will harden and heal, leaving a marked scar; the plant will grow until it becomes bushy and begins to run, then in the first hard wind will snap off at the point of injury. Galloway[1] found that the adult insect was capable of disseminating a bacterial disease of melons and related plants.

Comparative few facts have been collected to show the extent of the injury, but Fitch[2] speaks of it as the "worst insect in our gardens" and Riley[3] maintains it is "an insect which annually destroys thousands of dollars' worth of vines in the United States." Judging from the report of Sirrine's experiments in Long Island, the insect, when abundant, is fully capable of destroying 100 per cent. of the unprotected crop, and at least 10 per cent. of that part of the crop for the preservation of which a struggle is made.

Measures for Control.

The fact that the beetles could be driven away temporarily and the plants rendered distasteful by the careful application of a dust or spray, and that in some seasons such treatment was sufficient to protect the cucurbits from their ravages, led to experimentation with a host of substances that acted purely as repellants. Among those, with little or no practical value, may be mentionea charcoal, soot, road dust, saltpetre, cow manure, chicken manure, burdock infusion, "Slug Shot," hellebore, rags and corn cobs soaked in kerosene, bi-sulphide of carbon, land plaster, and X.O. dust. Among those that have proven more useful are ashes, air-slaked lime alone or with arsenites, tobacco dust, and Bordeaux mixture alone or with Paris green. In the course of our experimental work a number of these substances were tried, and in order that the basis for our conclusions may be plain, I will briefly describe the experiments. Half an acre of cucumbers was divided into 10 plats, and two and one-half acres of squash were divided into 8 plats. Each of the first six treatments was applied to both cucumbers and squash. These were: Bordeaux mixture (3 pounds copper sulphate, 4 pounds of lime and water to make fifty gallons); Bordeaux plus Paris green; "Bug Death"; tobacco dust; road dust; arsenate

1. "Insect Life," Vol. VI, p. 122.
2. l. c., p. 433.
3. Second Ann. Rept. on the Noxious, Beneficial and Other Insects of the State of Mo., 1870, p. 64.

of lead, 3 pounds to 50 gallons of water. Hammond's "Slug Shot," sulphur, air-slaked lime plus sulphur, were applied to three other plats of cucumbers, and arsenate of lead, 6 pounds to 50 gallons of water, was applied to another squash plat. The treatments were applied as soon as the beetles appeared and renewed as often as necessary to keep the plants well covered. The beetles were only sufficiently abundant to destroy about one-fourth of the plants in the check plats, but the effect of their work appeared in the setback the plants of these plats experienced. In perfect agreement with the finding of others, the road dust proved to be of little or no value. "Slug Shot" and sulphur appeared to partially protect the plants from the beetles, but seemed seriously to check their growth. "Bug Death," on the other hand, appeared to be as useful as tobacco dust and to afford pretty satisfactory protection without doing noticeable injury. The air-slaked lime and sulphur combination proved quite as useful as the tobacco dust. Bordeaux mixture so seriously checked the growth of the plants treated that the plats on which it was used made decidedly less growth. Arsenate of lead gave just as perfect protection as the Bordeaux or any of the dusts, and did not appear to injure the plants in the least. The arsenate of lead plats made the best growth of any, and the cucumber division produced the earliest cucumbers in the patch. Three pounds of arsenate of lead to 50 gallons of water, seemed just as effective as six pounds.

Many efforts have been made to find some other way of killing the beetles than hand-picking. Gillette[1] found that dry pyrethrum dusted on the plants while the dew was on would kill many of the insects. He records the finding of 280 dead beetles about forty hills of squash that had been treated with this substance. Smith[2] found that sludge-oil soap would also destroy the beetles. Sirrine[3] found that the insects could be successfully poisoned only twice during the year, because at other times they refused to eat plants covered with a foreign substance. These favorable times were between the time of emergence from winter quarters and the beginning of pairing, and in the fall when food becomes scarce. In 1907 the beetles were paring when they attacked the cucurbits and fed on blossoms of these plants until frost. A favorable time for killing

1. Bul. No. 5, Iowa Agric. Expt. Sta., 1889, p. 176.
2. Rept. of Agric. Expt. Sta. of N. J., 1890, p. 482
3. l. c., pp. 6 and 12.

the beetles did not arrive, but this is the record of only one year. Although we kept young and tender squash plants dusted with Paris green throughout the time the general experiment was in progress, we were unable to poison the beetles with either Paris green or arsenate of lead. They would not eat the parts of the plant covered with the poison. Sirrine[1] found trap crops very useful on Long Island in saving regular crops, and our experience in New Hampshire would indicate that they might prove valuable there, for when plenty of clean, tender squash plants were to be had, the beetles avoided the treated cucumbers and squashes. Squash plants may be used as traps

FIG. 41. Wire covers for melons.

for both of these crops, provided the latter are covered with some foreign substance to render them distasteful.

In cases of extreme infestation, covering the plants seems to be the only means of saving them. Before 1852, more than 13 years before the natural history of the insect was understood, covers were recommended[2] as a means of preventing its damage, and during the succeeding years many types have been devised and described. Among these may be mentioned: the box covered with cloth and later with wire; a piece of cloth sup-

1. l. c., pgs. 14-16.
2. Insects Injurious to Vegetation. Harris, Third Edition, 1862, pp. 125-126.

ported by the half of a barrel hoop, set over the plant like a croquet wicket, or by two of these set at right angles, or by wires set like the barrel hoops; cloth nailed to the one side and two ends of two rectangular boards each ½" x 6" to 8" x 16" and furnished with a sharp stake projecting from the side opposite to the one on which the cloth is nailed to be thrust into the ground on each side of the hill in such a way that the cloth will be stretched and the loose edges may be rendered beetle-tight by putting soil on them; planting the seed in holes 5 or 6 inches deep and covering them with a sheet of glass; wire plate-covers, etc. In our work we found that a useful type of cover may be made as follows: Secure yard-wide screen wire of slightly smaller mesh than the ordinary window screen and cut off one yard; the piece will then be one yard each way. Describe a circle on this piece, having a diameter of 36 inches, and cut off the corners. Then divide this circular piece of wire into two equal parts, fold the straight cut equally upon itself, bend the two edges over together twice and hammer them down firmly. Thus, a cone-shaped wire cover, costing a few cents and capable of withstanding several years' wear, is ready for use. Two covers can be made of each square yard of wire. The greatest objection to the use of covers lies in their cost, although some investigators have suggested that they may weaken the plants, especially if left on too long. For the kitchen garden or for fancy vegetables, covers will prove useful and practicable, when the bugs are especially abundant or when time does not permit the use of other measures. The time comes, however, when the plant has reached such a size that the cover must be removed. If the beetles begin to injure the plants seriously at this time, they must be treated with tobacco dust or arsenate of lead, or, should the plants be threatened with fungous diseases, they should be treated with Bordeaux mixture instead of the tobacco or lead.

In New Hampshire the grower who expects to raise large acreage and to dispose of his crop at other than fancy prices, will probably get the best results from a combination of methods such as the following: A week or ten days before the regular crop is set out, plant squash-seed around the prospective field and through it at intervals, if it be large. Plant more trap-squash seed when the regular crop is put into the ground. From the first appearance keep the regular crop thoroughly covered with arsenate of lead (applied with a sprayer at the rate of three pounds to 50 gallons of water) or with tobacco dust, if

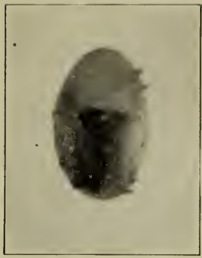


Fig. 1.—Egg, enlarged.

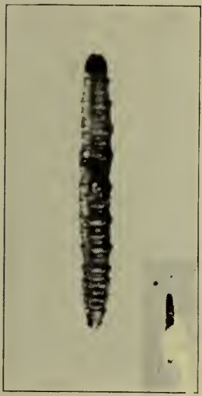


Fig. 2. Larva, enlarged and natural size

Fig. 3. Pupa in earthen cell, enlarged.

Fig. 4. Pupa, enlarged and natural size.

Fig. 5. Adult beetle, enlarged and natural size.

THE STRIPED CUCUMBER BEETLE (*Diabrotica vittata*.)

preferred. Plant another set of trap squash seed a week or ten days after the main crop has been started. As soon as the plants of the main crop begin to run, if they are cucumbers, the tobacco or lead treatment should be stopped and the plants treated thoroughly with Bordeaux mixture to protect them from fungous disease. It is possible that when cucumbers are to be protected so many of the beetles will congregate on the trap-squash that treatment of the cucumbers may be unnecessary. The grower will find that the rapid growth induced by good

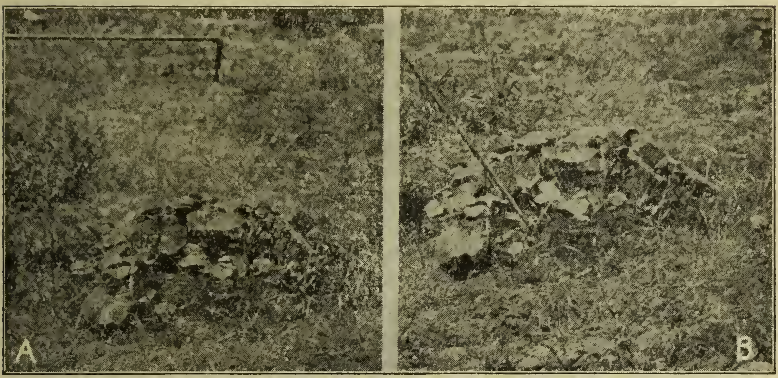


FIG. 42. Spray rod with nozzle attached at right angles to facilitate spraying from above as shown at A, and from beneath as at B.

fertilizing will help the plants quickly to grow beyond the power of the beetles to harm them. As Smith suggests, clean farming, by depriving the adults of good wintering places close at hand, may go far toward reducing the number to be contended with the following spring.

The larva of the striped cucumber beetle does so comparatively little damage that small effort has been made to find a way of combating it. Fitch's suggestion that covering the plants will probably enable them to escape the work of the larva, seems the best for which our present knowledge gives basis.

THE ANTLERED MAPLE CATERPILLAR.

Heterocampa guttivitta Walker.

C. F. JACKSON.

Of the many insect enemies of our forest and shade trees, perhaps none has caused more general alarm during the past year than the Antlered Maple Caterpillar. Being comparatively unknown by people in the state, its sudden appearance and the complete defoliation of large tracts of valuable woodland were sufficient to alarm not only the lumbermen but also the summer residents and farmers.

So far as known this insect has never before attracted attention or caused any appreciable damage, except in Maine in 1907. In fact, on an extended trip through the infested region but one or two persons could be found who remembered ever having seen the caterpillar before.

To the entomologist, however, this species is not new, the adult having been described as early in 1855 by Walker in the "Catalogue of the Lepidoptera of the British Museum," and named, *Cecrita guttivitta*. Later (1880) the larva was first described by French. In 1895 Packard gave an extended account of the life history and distribution in his "Monograph of the Bombycine Moths." He notes that the larvae feed on a variety of trees, but up to that time had not been numerous enough to attract any attention. The first serious outbreak seems to have been in Maine within the last three years, when great areas of valuable forest were defoliated, (1907. Patch, E. M., Me. Agr. Exp. Sta., Bull. 148.), while in New York considerable damage resulted from attacks of this insect during 1907. Judging from these facts it seems plausible that this pest has been gradually increasing within New Hampshire until the present year, which has been unusually well adapted for its development.

General Description and Life History.

The adult form of the Antlered Maple Caterpillar may be described as a mottled-gray moth densely covered with scales, and the wings marked with scalloped cross bands. The moth is of medium size, and when resting on dead leaves is scarcely visible so perfect is its protective coloration. Like the remainder of this group it is nocturnal in its habits, flying only at night, at which time the eggs are probably deposited. Con-

cerning this habit but little or nothing is known. Eggs have been found at Brunswick, Me., July 3 (Packard), hatching about a week later.

It is from the first larval stage that this species takes its name. The larva, as described by Packard, is about 5 mm. long, of a uniform dark chestnut or reddish brown, the body tapering from the head backward, and "possessing at this stage an extraordinary armature of nine pairs of enormous horns like those on a deer. The prothoracic pair are nearly three times as large as those on the first abdominal segment." Following this stage a radical change occurs before the larva reaches its full development, the horns or tubercles being lost, and the color changing from brown to green.

The full-grown caterpillar varies greatly in its general appearance. It is a green caterpillar, about 40 mm. (1 3-5 in.) long, with a purplish-brown, saddle-shaped marking near the middle of the back. In the last stage before pupation all the purplish-brown may be lost, the worm having a uniform green color. Some, however, seem to retain the brown, while others are green almost their entire life.

After feeding for about four weeks the larvæ drop to the ground and crawl under the leaves, where the change to the pupal stage occurs. The pupa is about 18 mm. in length, of a dark reddish brown, and extremely difficult to distinguish from the pupæ of many other members of this group. It is in this stage that the winter is passed, the adult moths issuing the next June.

Technical Description of Adult. General color pale ash gray, a silvery cast in certain lights, an olive green reflection in others. Fore wings mottled with dark and light patches, the veins being nearly black. Head and base of antennae yellowish, palpi ash-colored. Eyes brownish black. Thorax ashen, much darker along posterior edge, and near base of wings. Tips of fore-wings lighter than base, of a greenish cast, and edged with a fine fringe, at the base of which is a black line connecting the veins. A double row of very faint scalloped markings cross the wing about two-thirds the distance from the base. Midway between the base and tip of the wing is a crescent-shaped mark of ash-bronze.

Hind wings ash gray, light at base, dark toward tip, and along costal border. Base of wings covered with long, fine hair. Distal margin fringed and marked with black as in fore wing. Trace of a whitish line across wings, more distinct near costal

border. Veins dark, as is the fringe at the terminus of each vein.

Body ash, mottled with black and white. Under part of wings and thorax ash white, thorax covered with long, silken hairs on under side.

Length 16.5 mm.; wing expanse 38 mm.

The difference in appearance of the sexes is very slight, the foregoing description being that of a female. According to Packard considerable geographical variation seems to occur, but in looking over a number of New Hampshire specimens very little, if any, variation was evident.

Habits of the Adults. As already mentioned but little is known of the habits of the adult moth. From observations in the laboratory the moths are entirely nocturnal in their habits, remaining quiet in the daytime when they may be easily captured. The eggs are probably deposited on the leaves, egg deposition extending over a considerable length of time, for the species, if not for the individual, as larvæ of all sizes were found July 20, although on that date by far the larger number were ready to pupate. There seems, also, to be a tendency to a second brood, as one moth emerged the first of August and others appeared later. From this it seems reasonable to expect the adults any time during the spring and summer. Several moths, which I think were of this species, were taken at Tamworth, July 20-25, resting on the bark of beech and maple trees, a number were also taken by means of a trap lantern at night. However, they were in too battered a condition to make identification certain. The last moth to emerge in the laboratory was October 15, but beyond a doubt this was unusual, although the temperature conditions were about normal.

Description of Larval Stages. The exact period of incubation for this species is not known. However, emerging from the egg is one of our most peculiar larvæ. According to Packard, "The larva is the most remarkable of its family, in possessing at this stage, an extraordinary armature of nine pairs of enormous horns like those of a deer. The prothoracic pair are nearly three times as large as those on the first abdominal segment, and arise from a dark piceous plate, each horn is stout, about twice as long as the body is thick, with two stout acute tines reaching forward and outward, and a third upward, with a fourth small sharp one projecting in front near the base; each tine bears a hair arising from near the end. The tines are, more or less, rough and finely spinulose, especially on the opposing

bases of those projecting upward and backward. The second and third thoracic segments are smooth, and unarmed, and much wrinkled transversely. On the first abdominal segment is a pair of long, slender horns with the distal third, smaller and bent forward and outward, with the end thickened and bearing two or three minute spinules, and a single long hair; this pair arises from a large, black, dorsal undivided plate, while those behind (on second to seventh segments) arise from a more rounded black plate, divided into two half-moon-shaped pieces by a distinct greenish yellow space. Those of the second abdominal pair are much smaller than the pair in front and those behind. Those of the third abdorminal segment are not so large as the first, but much longer than those behind. The pair on the eighth abdominal segment are of the same size and shape as those on the first abdominal segment, but are slightly shorter. The suranal plate is rounded, convex, shining black, giving rise to a pair of black horns shorter than the shortest ones in front. Thoracic legs blackish; the middle abdominal legs of a pitchy color."

This stage lasted nine days, during which time it fed on the under side of the leaf, eating out little irregular patches.

Following this stage a radical change occurs, the larvæ assuming an entirely different aspect. The reddish-brown color of the body is still retained but all of the tubercles are lost, with the exception of those located on the pro-thorax. These latter are much smaller than in the first stage, consisting of but a pair of short, straight horns. Numbers of larvæ in this stage were found at Tamworth, July 20. However, most of these were in badly-infested regions where the food supply was limited, probably retarding their development. Great variation was noted, both in the size and color, many individuals having nearly the same markings as the mature larvæ, but still retaining the horns.

Following this stage it is almost impossible to separate the larvæ into definite groups, although Packard describes three more distinct stages. In looking over an unlimited number of specimens three general types may be found, although they grade inseparably into each other. The following description will apply to a large majority of healthy, full-grown larvæ just before the last stage is reached:

Head, lemon yellow, a blackish-brown streak extending from vertex over either eye to bases of palpi, forking just before reaching mouth parts. Another spot of the same color on the

ventral margin of the genae. A crescent-shaped row of five small tubercules just at the base of the palps. Length of head from apex to edge of labium, 4 mm.; width, 3.5 mm.

Body, greenish straw yellow, marked with dark reddish-brown and chrome yellow. Sides of entire body covered with fine brown dots. First thoracic segment with a short transverse ridge, yellow, marked with two lateral brown spots. Two faint median dorsal brown lines on thorax II and III. Thoracic legs a light brown, a shiny black spot on the outer aspect of the second segment.

Dorsal portion of abdomen marked with one median light yellow line, with two parallel chrome-yellow lines on either side. Abdomen III with two dorso-lateral spots of deep brown. Abdomen IV with a median spot of same color, and abdomen V with a similar V-shaped marking. Two smaller median spots on abdomen VII and VIII. Lateral dark brown markings consisting of three pairs of stripes extending from the lateral line to the base of thoracic leg III, and pro-leg I and IV. The ends of all the pro-legs marked with the same color. A ventro-lateral spot on abdomen VII. With the glass may be seen a very sparse covering of fine hair. Total length 40 mm. Greatest width at segment IV, 5.5 mm.

A comparison of a second type shows a great reduction of the brown color. The general tone is lighter, eyes marked with an inner line of black and an outer of brown. No other brown on head or body except a small V on abdomen IV, and a sparse sprinkle of brown dots on the sides. End of feet and pro-legs black. The yellow markings similar to above, but lighter.

Mature Larva. Despite the fact that such a large amount of variation occurs in the intermediate larval stages, we find that the last stage before pupation is fairly constant as to the general color pattern. The body assumes a dull, dirty green color, and becomes short and thick. All of the brown, saddle-shaped markings are lost, the only trace of brown being a number ot fine dots along the sides of the body, and in many instances even these are not present. As a rule, however, the brown is replaced by a dorsal band of white and two lateral bands of the same color. But little, if any, food is taken during this stage, the larva changing in a few days to the pupa.

Habits of Larvae. Our attention was first called to the depredations of this larva by Mr. Eliot C. Clarke of Boston, whose summer home is near Tamworth, New Hampshire. Mr. Clarke informed us that a vast colony of green worms had suddenly

appeared, stripping hundreds of acres of forest land in various sections of the Sandwich Range of mountains. Following Mr. Clarke's communication came numerous inquiries concerning the "green caterpillar," which was said to be sweeping the forest of all vegetation through the town of Tamworth. Within two or three days the mail of the Station Entomologist was practically doubled. For this reason a personal investigation was at once begun to try and determine the facts concerning the outbreak. In this work the greatest assistance was rendered the writer by Dr. Wm. Rollins, whose summer home is also near Tamworth.

In driving through the country one's attention was at once attracted by the vast tracts of brown woodland, broken only here and there by small clumps of pine trees. On the farm of Mr. Eliot C. Clarke, eight miles west of Tamworth, was one such-infested area which was carefully studied, and is quite typical of the section. The tract of land under consideration was located in the foothills of the Sandwich Range, at something over one thousand feet elevation, and was probably a mile or more in diameter. The timber consisted principally of maple, birch and beech, with a small variety of shrubs and other trees.

This region was very distinctly divided into three zones. The first, or central portion, comprised an area of several hundred acres, which was entirely stripped of all foliage. However, beside the conifers there was one peculiar exception, the striped maple or moosewood (*Acer pennsylvanicum*) was apparently unharmed, bushes in full leaf being in evidence in all parts of the forest. In this central area few, if any, larvæ were to be found, although I was informed that about a week earlier the rocks, trees and ground were literally covered with one great crawling mass of green caterpillars, but by the time I arrived nearly all of these had either starved or begun preparations to pupate. Just beneath the leaves were countless numbers in all stages of pupation. Probably a third of those attempting to pupate were so weakened by starvation that a complete transformation was impossible. Large numbers of partially formed pupæ were found dead, beside quantities of larvæ which had only reached the third stage, but were enclosed in their thin silken cocoons ready to pupate. This was undoubtedly caused by the entire lack of food, the partially grown larvæ taking refuge under the dead leaves.

The second zone varied in width from a few yards to several rods, and entirely surrounded the first. This zone was charac-

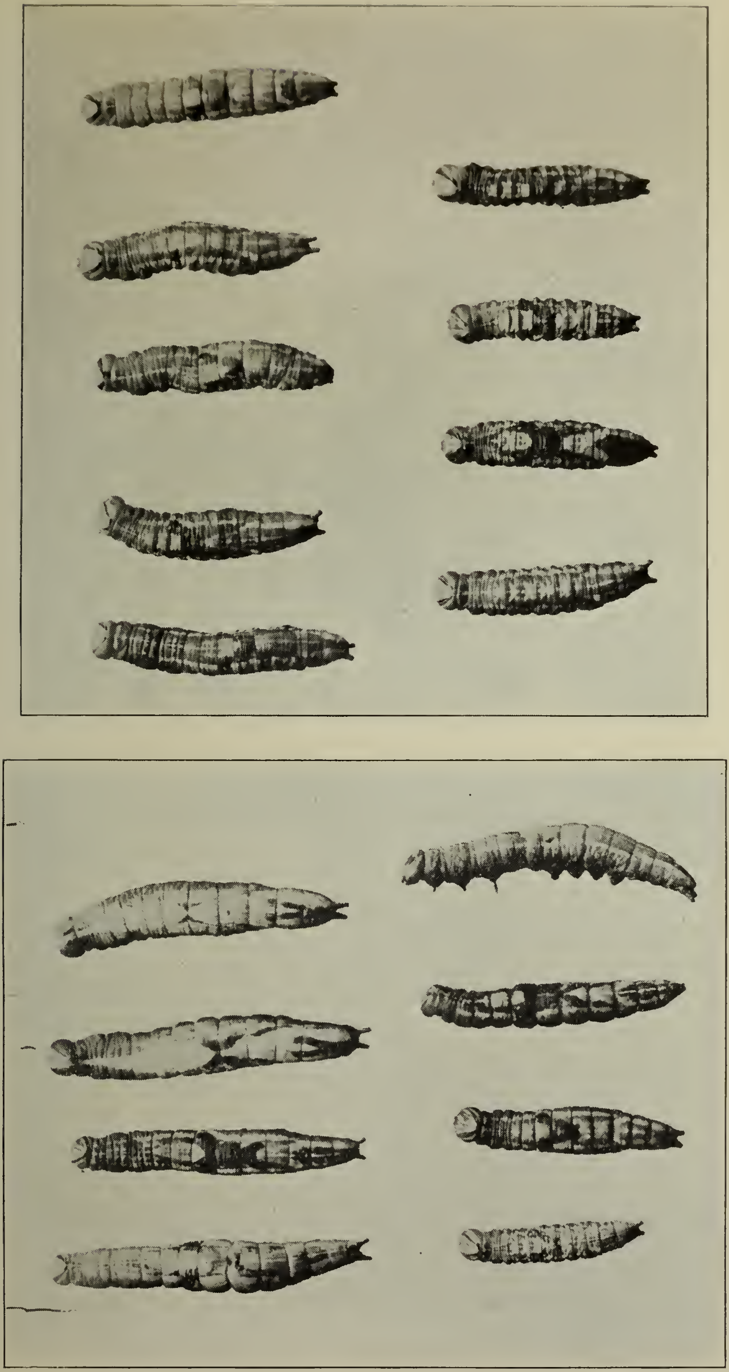
terized by countless myriads of larvæ in all stages of growth, as well as in all stages of starvation. The trees were not entirely denuded of foliage, but covered with larvæ which were rapidly completing the work. Everywhere was to be seen one vast crawling mass of green caterpillars, and the noise made by the falling excrement and bits of leaves sounded like an April shower. In the mountain streams bushels of caterpillars were collected in the eddies, their decaying bodies causing a decided stench. It was this crawling mass of caterpillars that gave foundation for the general impression that the larvæ migrated in mass from a stripped section of the forest to one where food was plentiful, something on the order of the army worm. A careful study was made of the problem with the result that no migration whatever could be detected, except what would accidentally occur from the worms crawling about. All of the larvæ observed were, technically speaking, negatively geotactic, that is, they had a tendency to crawl up any perpendicular object they came to whether it were a tree, rock, stump or weed. The fact that the larvæ were on the ground at all is explained by the countless numbers feeding on a tree at one time. In feeding, the larva eats out crescent-shaped areas from the leaf, frequently cutting off a considerable portion of it which falls to the ground, in many cases carrying the larva with it. In other instances as the foliage is stripped from the tree, the larvæ crawl to the outmost twigs in search of fresh leaves, and may be either blown off, or drop to the ground. These, starting out in any direction, are as likely to crawl up a pine tree as any other. Those larvæ not successful in finding food crawl about until, weakened by starvation, they fall to the ground again, only to repeat the search. In this way the infested region would be pushed farther and farther away from the original colony, but during the entire season could not be extended over much new territory. Even after the larvæ are ready to pupate it seems doubtful if they crawl down the trunks of the trees, but more likely simply drop to the ground. Beyond much question this second zone was made up of larvæ which had been fortunate enough to migrate in the right direction from the original infested area. On one side of this area was a pasture, which was searched for several hours, but no caterpillar could be found any distance from the trees. This fact, also, led me to further doubt there being a migration.

Extending for a mile, or more, on all sides of this badly infested zone was an area in which the larvæ were quite numer-

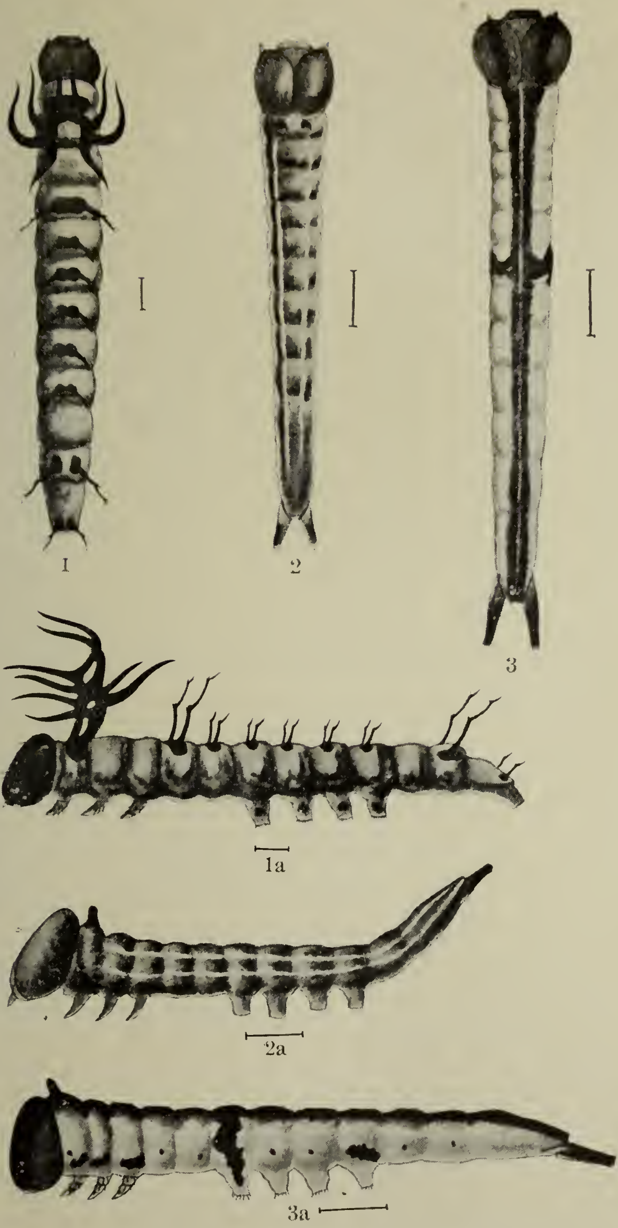
The antlered maple caterpillars assembled at the base of a tree. Tamworth, N. H., July 17, 1908.

Antlered maple caterpillars among the leaves in a woodland. Tamworth, N. H., July 16, 1908.

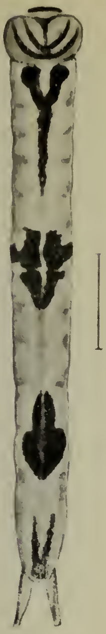
Pupae of the antlered maple caterpillars among the leaves at the base of a tree.



The antlered maple caterpillar, about natural size, showing the variations in markings.



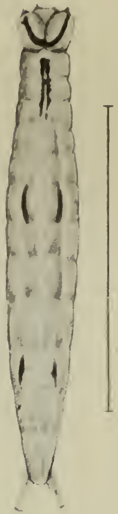
The antlered maple caterpillar (*Heterocampa guttivitta* Walk.) Fig. 1. Stage I; 1*a*, side view. Fig. 2. Stage II; 2*a*, side view. Fig. 3. End of stage II; 3*a*, side view. (After Packard.)



4

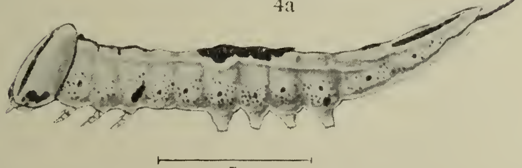
5

6

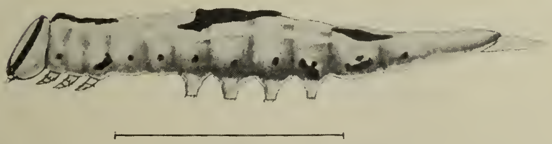


7

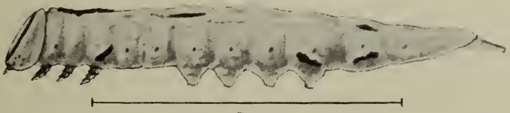
4a



5a



6a



7a

The antlered maple caterpillar (*Heterocampa guttivitta* Walk.) Fig. 4. Stage III; 4*a*, side view. Fig. 5. Stage IV; 5*a*, side view. Fig. 6. End of stage IV; 6*a*, side view. Fig. 7. Stage V; 7*a*, side view. (After Packard.)

Woodland defoliated by the antlered maple caterpillar at Tamworth, N. H., Aug. 4, 1908.

A little further in the woodland shown in plate 28, showing the work of the antlered maple caterpillar on maple, beech and birch.

Edge of woodland defoliated by the antlered maple caterpillar. Tamworth, N. H., July 16, 1908.

ous, but not at all conspicuous. In walking through the woods but few, if any, larvæ would be noticed. However, the ground was covered several inches deep in places with partly eaten leaves and excrement, which might be plainly heard constantly falling to the ground.

There seems no adequate explanation for this mode of distribution, although it was essentially the same in every locality studied. Possibly the central area may have been more or less seriously affected in past years, the outer area representing the extent of migration of the adults for one season.

Concerning the food plant, with one or two exceptions, but little preference is shown between various hardwood trees. Practically everything is taken with the exception of the "moosewood." There is, however, a preference for maple and beech, while the white oak and yellow birch are left until the last.

In feeding the larvæ cling to the under side of the leaf, and, beginning at the outer edge, eat out large crescent-shaped areas. Frequently, two of these areas uniting will cause the outer portion of the leaf to fall. Whether or not the younger larvæ feed in colonies is not known, but the more mature forms do not appear to be gregarious in their habits.

When about ready to pupate the larvæ drop to the ground or let themselves down by silken threads, then work their way under the leaves to a depth of from two to six inches. It seems quite probable that the larvæ molt after leaving the trees, the form usually found beneath the leaves being quite different from the ones on the trees.

Pupae and Pupation. After the larvæ have worked their way well beneath the leaves preparations are begun to enter the pupa stage. This is a very simple process as compared with the elaborate cocoons made by some of our moths. In this instance the larva works out a simple, small cell, but little if any silk entering into the composition. However, several larvæ kept in the laboratory worked their way beneath the dirt and spun quite firm cocoons, which were covered with particles of dirt held firmly together by silk threads, while the interiors were lined with silk and perfectly smooth. The length of time consumed in this preparation is not known, but the transformation takes place within a week or ten days after the larvæ leave the trees.

The pupa may be described as follows: Body stout and thick, head somewhat pointed, mesoscutum firmly corrugated, or nearly smooth, abdomen covered with slight depressions. Beside the mesoscutum are from six to ten quadrangular, flattened, unpol-

ished tubercules, each with a slight median depression. The two terminal spines of the abdomen have a very characteristic shape. Each ends in an enlargement resembling a foot with the heel pointing inward and the toe outward. Vestiges of the anal legs and genital openings indistinct. General color dark reddish-brown. The winter is passed in the pupa stage, but some of the moths emerge during the late summer or early fall. Whether a sufficient number come out to produce a second brood or not remains to be determined. Large numbers of pupæ were found July 20, so it seems quite probable there may be a small second brood.

Relation to Other Heterocampae. All the moths of this group look very much alike, there being a close relationship between not only the members of the genus *Heterocampa*, but also the adults of the entire family *Notodontidae*. There is much similarity in markings, as well as other details of structure. In a synopsis of the genera of the sub-family *Heterocampinae*, Packard gives the following distinguishing characters: "Fore-wings produced toward the apex, outer edge usually very oblique; a long subcostal cell, hind wings short and rounded, male antennae filamental at the end, larvæ varying from being simply nocturiform to having long substenapodiform anal legs." Of the seven genera which constitute this sub-family none are well marked, grading off almost insensibly into one another. The usually short hind wings with their well-rounded apexes, the broad stout palpi, and the very hairy thorax, are apparently the chief characters.

Twelve species belong to the genus, all with very similar markings, but in *H. guttivitta* the markings are less distinct than usual, the fore wings ash-gray, and, according to Packard, usually a discal mark, enclosed in a large diffuse lunate pale ashen patch. The latter mark, however is not always distinct.

The closest allied form of this particular species is *H. biundata*. On casual examination these two forms appear almost identical. But all the specimens studied of *H. biundata* have two definite brownish scallop-shaped bands crossing the base of the fore wing which are either very faint or entirely lacking in *H. guttivitta*. The general coloring of *H. biundata* is lighter, with a yellowish tinge, while the markings are much more distinct, the wings and the thorax are marked with a deeper brown than in *H. guttivitta*. The larva of *H. biundata* has a more pointed head than *H. guttivatta*, and lacks in the early stages the horns as well as the brown saddle-shaped mark, although a brown spot is usually present on the side of the body.

ASSOCIATED CATERPILLARS.

Two other forest insects which have been closely associated with *H. guttivitta* in the present outbreak, should be described here. One of these is known as the Striped Maple Worm (*Anisota rubicunda* Fab.). The adult worm is about two inches long, light green in color, with white stripes down the side. It may be easily distinguished from the preceding species by having at all stages of its growth two large black spines just back of the head, and a series of shorter spines along the sides of the body. This is by no means an uncommon maple pest, but seems to have been more abundant, than usual, this year. In the valleys and the more level sections of the state this insect has caused more destruction than *Heterocampa*, especially to shade trees. However, the defoliation has in no case been so complete.

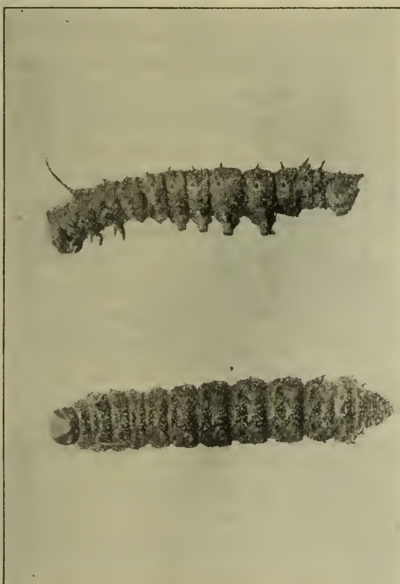


FIG. 43. The Spiny Oak caterpillar (*Anisota stigma*), natural size.

Another serious pest during the past summer was the Spiny Oak caterpillar (*Anisota stigma* Fab.) This worm resembles the preceding very much, but is of a dark brown color. This is a well known pest of the oak, but has been somewhat more numerous this summer than usual.

EXTENT AND CAUSE OF OUTBREAK.

The amount of damage caused by the attack of the Antlered Maple Caterpillar has already been suggested. Thousands of acres of woodland in various parts of the state have been entirely stripped of foliage, and other tracts more or less injured.

Several trips have been made by the different members of the entomological staff to the most seriously infested region. Mr. W. M. Barrows on Aug. 14 visited the region lying between Lake Winnipesaukee and Lake Sunapee. In his report Mr. Barrows states that the maples in this section were badly stripped, but the basswood, ash, oak, etc., were not badly eaten. All of the larvæ at this time were in the pupal stage, so it was not possible, in all cases, to tell whether the work was that of *Heterocampa* or *Anisota*, although numbers of *Heterocampa* pupæ were found particularly under maple. Numbers of mice were found working at the same level as the pupæ, many of which were destroyed. Upon inquiry it seems that mice have been very scarce through-

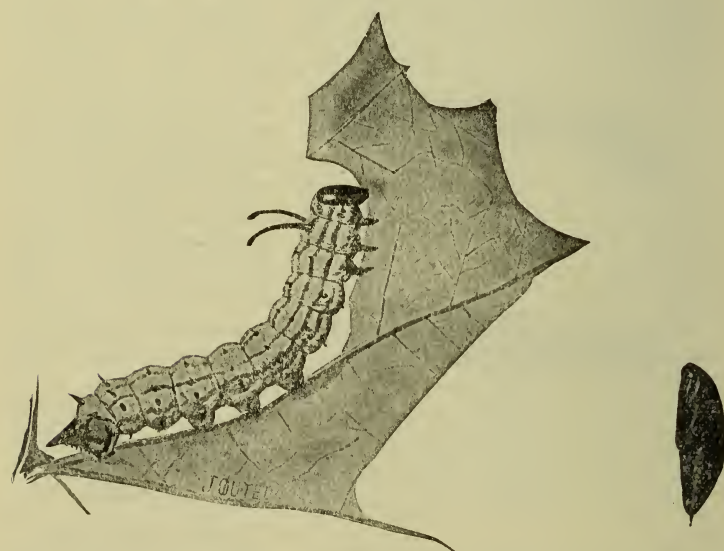


FIG. 44. The Striped Maple Caterpillar (*Anisota rubicunda*). (After Felt).

out this section within the past two years. It was also learned that the last winter was severe for the mice in many respects. There was very little snow but considerable ice, while the frost was very deep, and it was thought that the mice were killed off by the very severe winter or some other cause.

Birds are also extremely scarce, as on driving from Grafton to Bristol, a distance of fourteen miles, Mr. Barrows reports only having seen "one robin, one song sparrow and two large hawks,

there being no swallows, king birds or other insectivorous birds."

On Aug. 18, Mr. W. S. Abbott investigated the region in the towns of Sullivan, Keene, Hancock, Peterboro and the intervening region. Through this section he found the maples, birch, beech and ash badly stripped, the maple and beech being taken first. No larvæ or adults were found, but the pupæ were abundant in the leaves. In Sullivan was a wood lot of about a hundred acres which was badly stripped. In this region many parasites were found, about one-fifth of the pupae being broken open. In one case specimens of *Calathus gregarius* were found feeding on freshly broken pupæ. Carabidæ and carabid larvæ were rather plentiful among the dead leaves. At this place predaceous enemies were more numerous than in any other locality. Many of the maples which had not been entirely stripped by *Heterocampa* were being attacked by *Anisota rubicunda*. At Peterboro on the farm of W. C. Abbott was a row of maples which had been badly infested, but an early spraying with arsenate of lead had killed the worms, and the trees appeared uninjured.

Earlier in August Prof. E. Dwight Sanderson visited Tamworth, extending his trip up to Intervale and through the White Mountain region. From his observations the larvæ were not destructive in the White Mountain region proper, the last serious infestation being at Intervale.

On July 20 the writer visited Tamworth and vicinity, the results of which form the basis of this paper. Later in the season, Aug. 11, a trip was made through the towns of Sutton and Sunapee, southward through the intervening towns to Bradford and Henniker. In Sutton the work of *Heterocampa* was not so much in evidence except in two or three places. At South Sutton, in particular, were several hundred acres which were entirely stripped. However, there were but few hard-wood trees which had escaped the attack of this insect, the pupæ of which could be found in small numbers buried beneath the leaves. In the town of Sunapee in the region lying nearer the lake the larvæ of *Anisota rubicunda* were quite numerous, while but few *Heterocampa* pupæ could be found. Through the towns of Goshen, Newbury and Bradford were many large tracts of hard wood completely stripped, though there is no doubt but that *Heterocampa* was greatly assisted in this by *Anisota rubicunda* and *Anisota stigma*, as these larvæ were quite numerous everywhere. Through the towns of Warner and Henniker the work was still less evident, there being but few patches entirely defoliated.

It is hardly probable that the attack this year will prove fatal to many of the trees, but if renewed another season many of the trees will, beyond a doubt, be seriously injured or killed. Numbers of the maple groves that were defoliated early in the season sent out a second growth of leaves, but these would assist very little in the nutrition of the trees.

New Hampshire is by no means the only state that has suffered from the attacks of *H. guttivitta* this year, Maine, Vermont and New York having all had serious outbreaks.

So far we can only conjecture as to the cause of the apparently sudden outbreak. It seems probable that these worms have been multiplying for some time, but have been so well protected in the dense forests that their presence has not been detected. On the other hand, there seems little doubt that the species has been held in check by parasites, or other natural enemies, which for some reason were unusually scarce this season, allowing the caterpillars to multiply abnormally. During the entire summer, in which large numbers of larvæ were reared in the laboratory, but one species of parasite was found (an *Ichneumon*) and that occurred in only two larvæ. Usually half the larvæ of our moths and butterflies which reach any size in the open, will be found to contain parasites. According to Miss Edith Patch of the Maine Agricultural Experiment Station, *Ichneumon sublatus* was quite numerous this season in Maine. This is probably a natural parasite of *Heterocampa*, which for some unknown reason became very scarce, allowing the host to multiply to such an appalling extent. Of the predaceous insects but two were at all numerous. The Fiery Ground Beetle, (*Calasoma calidum*), was quite plentiful in different parts of the state. This large bright-colored beetle doubtless destroyed great numbers of the caterpillars, but in the worst infested regions the beneficial results were not very apparent. The other predaceous insect, one of the soldier bugs, *Podissus placidus*, far outnumbered the ground beetles, and might be seen busily sucking the juices from the larvæ in almost any infested area.

Another factor in the outbreak was the noticeable scarcity of birds of all kinds. Not that this was the prime cause for such large numbers of caterpillars, but their numbers would evidently have been greatly reduced had there been more birds in the woodland. In many sections of the infested region one would travel all day, and not find half a dozen birds of any description. As before stated, Mr. W. M. Barrows in driving from Grafton to Bristol, a distance of fourteen miles, reports having

seen but one robin, one song sparrow and two large hawks, and the writer in traveling from Bradford to Henniker, a distance of ten miles, saw only four sparrows and one black-bird. But few or no birds were present in the badly infested region of the Sandwich Range.

Again, the ground mice and shrews do much toward holding these insects in check. Judging from the habits of these little animals they destroy many of the pupæ during the winter months. Mr. Barrows reports having found large numbers of empty pupæ cases in their burrows. The general opinion seems to be that the mice have been unusually scarce during the past few years. Still, we have no absolute data on the subject.

Weather conditions, in a general way, may have had considerable influence on the outbreak. If a combination of weather conditions existed which was detrimental to the parasitic or predaceous enemies of *Heterocampa*, but on the other hand was not beneficial to the species itself, a noted increase would naturally result. That climatic conditions were more or less responsible seems to be indicated by the peculiar local distribution. In all cases personally observed, the most serious outbreaks have been at elevations of from eight hundred to a thousand feet. Frequently a very definite line could be drawn on the mountain-side, above which the trees were completely defoliated, and below which there was no perceptible injury. However, we can only guess as to what extent this was dependent upon climatic conditions.

Many of the larvæ were found diseased, but no large proportion were thus destroyed. It is quite possible that diseases may be an important factor in the natural control of the pest. If so, the very unusually dry summer of 1908 would have effectually checked the development of such diseases and thus permitted the abnormal increase of the caterpillars. But little can be predicted for the future until more is known of the habits, life history, and natural enemies. The probability is that the enemies will multiply sufficiently within a short time, to keep the larvæ in check, but if this does not occur the results are liable to be very serious.

Geographical Distribution.

The range of the Antlered Maple Caterpillar is in no way restricted to New England, it having been reported from Maine, New Hampshire, Massachusetts, Rhode Island, New York, Wash-

ington, D. C., Georgia, Iowa, Wisconsin, Florida, Maryland and Colorado.

Within the state of New Hampshire letters have been received from widely separated points, indicating a general distribution. The worst infested region seems to commence on the eastern slope of the White Mountains in the town of Bartlett, and extends southward, including Conway, Albany, Tamworth, Sandwich, the towns bordering Lake Winnipesaukee to Plymouth, and lying between that lake and Lake Sunapee, extending on south to Sullivan, Keene, Hancock and Peterboro. The three principal centers of infestation seemed to be Tamworth, Sutton, and Hancock or Peterboro. Between these centers the towns were more or less seriously infested, especially in the more rugged country, where, in fact, the greatest amount of damage has occurred. In but few instances was the damage very extensive below one thousand feet elevation. It must not be inferred from the above that the larvæ are only found in the localities mentioned; they have been found at Durham, and possibly occur in limited numbers throughout the entire state.

Some idea of the distribution and food plants may be had from the following partial list of correspondents:

July 11-20, '08. Tamworth, (numerous letters). Reported on: Maple, birch, beech, apple; less numerous on oak, wild cherry, poplar, butternut, gray birch.
July 15, '08. Snowville.—Apple.
July 15, '08. Chocorua.—Maple, birch, apple.
July 15, '08. Plainfield.—Beech, maple; less numerous on birch, oak, basswood.
July 17, '08. New London.—Apple.
July 18, '08. East Conway.—Birch, beech, maple, oak, apple.
July 20, '08. Greenhill.—Apple, maple, beech.
July 20, '08. Pequaket.—Beech, white oak, birch, rock maple, white maple; less numerous on ash, poplar.
July 21, '08. North Weare.—Hard wood.
July 21, '08. Madison.—Poplar, beech, apple, maple.
July 22, '08. Bristol.—Maple, oak.
July 22, '08. New Durham.—Beech, yellow birch, white birch, rock maple.
July 23, '08. Intervale.—Beech.
July 24, '08. Whiteface.—Hard wood.
July 24, '08. Ossipee.—Hard wood.
Aug. 3, '08. Plymouth.—Hard wood.
Aug. 3, '08. Sullivan.—Maple.
Aug. 4, '08. South Sutton.—Maple.
Aug. 7, '08. Middleton.—Maple, oak, beech, elm.

Aug. 10, '08. Elkin.—Hard wood.

Aug. 23, '08. New Hampton.—Maple, birch.

It is interesting to note that the outbreak in New Hampshire seems to be simply an extension of the infested region in Maine. According to the Circular of Information issued by E. F. Hitchings, State Entomologist of Maine, the attack has extended to the north and east from the Ossipee valley, including the towns of Bethel, Brownfield, Bridgton, Auburn and Fairfield, as well as numerous other localities in this region.

Methods of Control.

At present it seems almost useless to try to suggest any means of eliminating this pest from the vast forest areas which have become infested. The problem, however, is much more simple with shade and orchard trees where proper means of control are adopted.

The simplest and surest method is spraying, using an ordinary barrel spray pump and plenty of hose, so the operator may climb up in the tree, and be able to spray the outer and topmost branches.

The best arsenical spray for this purpose is the arsenate ot lead, from three to five pounds per barrel of water. This will probably prove most effective if applied as a mist spray, the spray being thrown from the body of the tree outwards against the under side of the leaves. There are two reason for this: First, a rain is less liable to wash off the poison from the under side of the leaves; and, secondly, the larvæ feed from the under side. In spraying for *Heterocampa* care must be taken to thoroughly drench the topmost branches, as the larvæ will be found there. From what is known of the life history, the spraying had best be done between the first and middle of July. The worms at this time may not be very much in evidence, but still may be easily detected.

As a further preventative the trees may be banded with sticky fly paper or tanglefoot, or building paper smeared with a thick layer of printer's ink, to prevent any larvæ that may fall to the ground from crawling up the trunks. This is particularly advisable if the sprayed trees are near a woods or other infected trees, which may not be sprayed.

Bibliography.

1855. *Cecrita guttivitta.* Walker. Lep. of Brit. Mus. Cat. Vol. 5, pg. 992.

1856. *Cecrita albiplaga.* Walker. Lep. of Brit. Mus. Cat. Vol. 7, pg. 1748.

1856. *Drymonia mucorea.* Herrick-Schäffer. Ausser. Schmitt. Vol. 1, pg. 514.
1864. *Lochmaeus cinereus.* Packard. Ent. Soc. Phil. Proc. Vol. 3, pg. 372.
1865. *Mesodaga sobria.* Walker. Cat. Lep. Brit. Mus. Vol. 32, pg. 413.
1867. *Heterocampa doubledayi.* Harris' Ent. Corres. Pg. 134.
1880. *Heterocampa pulverea.* French. Canad. Ent. Vol. 12, pg. 83.
1881. *Heterocampa pulverea.* Packard. U. S. Ent. Comm. Bul. Vol. 7, pg. 46.
1882. *Heterocampa guttivitta.* Grote. New Check List. N. A. Moths. Pg. 19.
1890. *Heterocampa pulverea.* Packard. U. S. Ent. Comm. Rept. Vol. 5, pg. 159. Adult described as *Lochmaeus cinereus*, pg. 398. Listed pg. 218, 424.
1890. *Heterocampa guttivitta* (?) Packard. Proc. Bost. Soc. Nat. Hist. Vol. 24, pg. 544.
1890. *Heterocampa guttivitta.* Dyar. Psyche. Vol. 6, pg. 178.
1890. *Heterocampa guttivitta.* Smith. List Lep. Boreal Am. pg. 31.
1892. *Heterocampa doubledayi.* Kirby. Syn. Cat. Het. Lep. Vol. 1, pg. 564.
1894. *Cecrita guttivitta.* Neumogen-Dyar. Trans. Am. Ent. Soc Vol. 21, pg. 207.
1894. *Cecrita guttivitta.* Neumogen-Dyar. Jour. N. Y. Ent. Soc. Vol. 2, pg. 117.
1895. *Heterocampa guttivitta.* Packard. Monogr. Bombycine Moths. pg. 230.
1896. *Heterocampa guttivitta.* Lintner. Rept. N. Y. State Ent. Vol. 11, pg. 265.
1899. *Cecrita guttivitta.* Smith. Ins. N. J. pg. 456.
1902. *Heterocampa guttivitta.* Dyar. List N. A. Lep. pg. 254
1906. *Heterocampa guttivitta.* Felt. N. Y. State Mus. Mem. 8. Vol. 2, pg. 727.
1907. *Heterocampa guttivitta.* Patch. Me. Agr. Exp. Sta. Bull. 148. pg. 262.
1907. *Heterocampa guttivitta.* Felt. N. Y. State Mus. Bull. 124. pg. 21.
1908. *Heterocampa guttivitta.* Hitchings. Circular of Information on Forest Insects. Me. Dept. of Agr.
1908. *Heterocampa guttivitta.* Sanderson. Press Circ. No. 11, N. H. Exp. Sta. Concord Evening Monitor, July 30, etc.
1908. *Heterocampa guttivitta.* ————. Boston Globe, Aug. 31.

FIG. 45. Map showing distribution of the Antlered Maple Worm in New Hampshire in 1908.

The species was injurious at the black dots.

REPORT OF THE DAIRY DEPARTMENT.

FRED RASMUSSEN.

The following is a brief report of the work of the Dairy Department from September 1, 1907, to November 1, 1908:

The dairy herd, not being under the supervision of the Dairy Department, the work of this department is confined principally to the manufacture and marketing of dairy products. As the department at present is practically without facilities for doing experimental work, its work during the last year has been of an educational, rather than experimental nature.

DAIRY SURVEY.

The principal object of the dairy survey is to make a study of the conditions of the dairy industry in the state in order to ascertain the difficulties and problems the farmer meets in the production, manufacture and marketing of milk, cream and butter. The information gathered is to be used as a guide in planning and carrying out experimental work, the result of which would be applicable to New Hampshire conditions.

Furthermore, a study of the existing conditions in the state will be a great help in answering adequately the many letters of inquiry received in regard to dairy matters, as well as to furnish much timely material for lectures on dairy topics for which frequent calls are received.

In order to get a general idea of the conditions in different sections of the state, the co-operation of the Granges was asked for to the extent of giving names of farmers making butter and selling cream and milk. A circular letter enclosing return postal was sent to 286 Granges. On May 30, 1908, 83 letters had been received. June 1st a follow-up letter was sent to the 203 Granges from which no replies had been received, resulting in 60 answers. In all, 142 Granges, or, 50 per cent., answered the correspondence.

The cards received from the Granges contained 551 names of farmers making butter, 196 names of farmers selling cream and 74 names of farmers keeping records of their dairy cows. The cards also contained information in regard to the demand for dairy butter, prices paid for same and whether there was an increase or decrease in the production of dairy products in the

community. Reports from 140 towns were received. Forty-four showed an increase, 27 reported conditions normal, while 37 reported a decrease in the production of dairy products. The price of butter varied from 20 to 35 cents with an average price of 28 cents per pound. One hundred and twenty-five towns reported a good demand for farm butter, while 15 reported demand as limited.

A circular letter, explaining the object of the proposed dairy survey, was sent each of the 921 farmers whose addresses had been retained. The letter contained a return postal with questions in regard to the extent of their business, method of handling and disposing of the product, and the desirability of the farmer having a representative of the station visit his farm. Nineteen per cent. answered the questions on the enclosed postal.

After having obtained, through correspondence, a general idea of the dairy conditions in different sections of the state and also having had from several farmers in each section an expression of willingness to co-operate with the station, work in the field was begun.

To assist in this work the services of Mr. John Daniel, a graduate of Massachusetts Agricultural College, were secured. Over 100 farms have been visited. Information has been gathered on methods of dairy farming and farm butter-making, and other dairy problems. In order to make a through study of the farm butter-making problem, the representative of the station carried with him a small Babcock test so as to get complete records on the yield and losses in butter-making under farm conditions.

Numerous demonstrations have been given in testing milk and cream with the Babcock test. As far as possible the samples tested were chosen, so as to show the practical bearing of the test on the daily operations.

To find a loss of 1.5 per cent. fat in a sample of buttermilk, or to find a cow that supposedly tested very low, test 6 per cent., or to find a man selling cream guaranteed to contain only 40 per cent., which tested 47 per cent., making a difference in his daily net income of $2.53, are results which can not help impressing upon the farmer the value of and economy of the Babcock test as a part of his dairy equipment.

Demonstrations have also been given in the scoring of dairy barns and dairy methods, using the score card recommended by

the Dairy Division, Bureau of Animal Industry, U. S. Dept. of Agriculture.

The work of the dairy survey has been encouraging, as much valuable information has been gained, as well as ideas for future work. Although a few men have been visited who did not appreciate the work of the Experiment Station, the great majority have shown a great appreciation of the work and have been very eager to gain new ideas and to accept such suggestions for improvement, as it seemed advisable to offer.

There is a desire on the part of most of the people to be in close contact with the work of the Experiment Station, a desire for more personal contact, as indicated by frequent inquiries as to the possibility of the station, also, giving demonstrations with spraying, or conducting fertilizer tests.

LECTURE WORK AND CORRESPONDENCE.

Since Jan. 1, 1908, fourteen lectures on dairy subjects have been given at Granges or other meetings. The total number of people addressed being 776. This does not include the lectures given in connection with the demonstration at the Concord and Rochester fairs, nor the small gatherings which have been addressed in connection with the work of the dairy survey.

Besides the routine correspondence of answering inquiries, much additional correspondence has been carried on this year in connection with the dairy survey. Approximately 1800 letters have been sent from this department during the year.

NEW HAMPSHIRE EDUCATIONAL BUTTER SCORING CONTEST.

In order that the Experiment Station might become familiar with the quality of the butter made in New Hampshire creameries and the method employed in its manufacture, efforts were made to start an educational butter scoring contest. Such contests have been carried on successfully in other states, and have proven a great benefit to the participants.

A personal letter explaining the benefits of an educational scoring contest, with a plan for carrying out the work, and twenty questions to be answered, were sent to the buttermakers and managers of the 48 creameries which were supposed to be in operation in the state. Seventeen creameries replied, five of which had stopped operations. Three were shipping cream to

Boston, three answered the questions but did not signify their intention of taking part in the contest, and six were in favor of the contest.

The answers to inquiries sent the buttermakers revealed that few records are kept of the dairy work in the creamery, that in several creameries cream for testing was measured instead of weighed, that in one instance milk and cream was still bought for a certain price per pound without regard to the quality. None of the creameries made water determinations of their butter, and the over-run was too low. All of these factors are of great importance in good creamery management and consequently to the success of the creamery.

From the difference in method employed in the manufacture, it would be expected that the percentage composition of New Hampshire butter would vary considerable. To obtain accurate information on this point, ten samples of butter were collected at the exhibit at the Dairymen's meeting at Whitefield, N. H., representing ten creameries in different parts of the state. The samples, upon chemical analysis, showed the following composition:

No.	1	2	3	4	5	6	7	8	9	10
Water	15.62	13.35	12.33	12.16	12.09	11.54	10.75	8.33	8.13	7.22
Fat	78.88	82.51	82.70	82.75	84.80	83.60	85.65	87.12	88.18	88.41
Casein	1.34	2.80	1.73	3.32	1.33	1.59	1.81	1.03	1.50	1.64
Salt	4.16	1.34	3.24	1.77	1.78	3.27	1.79	3.52	2.19	2.73

The lowest, highest and the average percentage composition is as follows:

	Lowest	Highest	Difference	Average
Water	7.22	15.62	8.4	11.25
Fat	78.88	88.41	9.53	84.38
Casein	1.03	3.32	2.3	1.80
Salt	1.34	4.16	2.82	2.57

An average water content of 11.25 per cent. is below normal, as compared with analyses from other states. The average water content of 221 samples, as analyzed by the Iowa Station was 13.21 per cent. An average fat content of 84.38 is not as high as would be expected with as low a water content. This, however, is due to a higher per cent. of casein and salt than is normally found in butter. Analyses made of 28 samples of butter entered in an educational butter scoring contest in South Dakota at the same time of the year, showed the average casein content of this butter to be 1.18 per cent., and salt content 1.67 per cent., which is 34 per cent, less casein and 35 per cent. less salt than is found in New Hampshire butter.

In further looking up the creamery industry it was found that several of the creameries from which no reply had been received, had either failed or changed from a buttermaking plant into a skimming station, shipping cream to Boston. Several creameries in the state have been bought by the milk contractors in Boston, and are operated as skimming stations.

As the success of a scoring contest is dependent upon the interest shown by the creameries, it can readily be seen that after finding so many of the creameries had either failed or changed into skimming stations, that it would be impossible to get entries enough to carry on a successful contest, and the project was therefore given up.

The many failures and changes in the creamery industry in New Hampshire are primarily due to the increasing demand from the cities for milk for direct consumption. It is very difficult for a creamery to pay the prices for milk offered by the contractors unless a special price is obtained for the butter and the creamery has the best management. Some of the creameries failed because they were too small, making the cost of manufacturing a pound of butter too high. A report from one creamery showed the cost of manufacturing to be 7 cents per pound of butter made. A lack of co-operation on the part of the farmers, as well as poor management, are also factors which have had much influence in the changes in the creamery industry.

HERD TESTING.

In order to stimulate the increasing interest in the improvement of dairy herds, and to obtain information in regard to methods of feeding and cost of production, the Experiment Station offered to test, free of charge to the New Hampshire dairymen, a limited number of dairy herds. Twelve herds, numbering 193 cows, are now being regularly tested by the Experiment Station, records being kept, not only of the amount of milk and butter fat produced, but also of the amount and cost of food consumed.

The following comparison will show the great variation in the cost of producing milk between two herds in February, having a proportionate number of fresh cows:

	Herd No. 1.	Herd No. 2.
Average cost of keeping a cow per day............	26.3c	20c
Cost of producing milk per can.	32.5	21
Selling price per can............................	34	31.5
Profit per can...................................	1.5	10.5

The loss sustained by Herd No. 1 is attributed to the following causes: (1) The breed of cows was better adapted for making butter or selling cream than for selling milk. (2) No study was made of individual cows in the herd. Some cows were fed too much grain, others not enough for a profitable production.

As soon as a year's work is completed the results will be published in bulletin form, giving practical suggestions on the improvement of the dairy herd.

TESTING PURE BRED COWS.

Requests have been made from several breeders of Guernsey, Jersey, Holstein and Ayrshire cattle, for the supervision of the Station in conducting weekly or yearly tests of their animals under the rules of their respective associations. During the last year there has been completed 15 Guernsey and 5 Holstein tests. Seven Ayrshires and two Guernseys are under test at the present time.

BULLETINS.

As soon as the work carried on at the present time is completed, the following bulletins will be published:

1. Report on the Dairy Survey.
2. Farm Buttermaking in New Hampshire.
3. Herd Testing.

EXECUTION OF DAIRY LAWS (ACT OF 1901).

The act demands that any person who operates the Babcock test, or, any other test, for determining the butter fat or solids in milk and cream, as a basis for apportioning the value of same, must hold a certificate from the proper station official showing the holder competent and well qualified to perform such work. The law, further, provides that all glassware used in connection with the testing must be tested for accuracy of graduations.

During the last year 33 candidates have been examined for a milk testing certificate. Two failed, while it was necessary for several to take a second examination.

Sixteen hundred and thirty-six pieces of glassware were examined for accuracy of graduation, of which 41 pieces, or, 2.5 per cent., were inaccurate or defective.

NEEDS OF THE DEPARTMENT.

The old college creamery has for several years been entirely inadequate, both for the needs of the college and station work. The department is very much in need of a Dairy Bactriologist and a laboratory for research work. At the present time the department is unable to get bacteriological work done, which greatly handicaps the work, as in a state like New Hampshire, where the production of milk for direct consumption is the main branch of the dairy industry, bacteriology, necessarily, plays the greatest importance in solving timely problems.

In all expermental work with dairy products, as well as in the study of dairy bacteriology, one of the most important factors is to be able to control and regulate temperatures. It would, therefore, be of the utmost importance to the experimental and research work of the department, to have suitable cold storage facilities.

The importance of the dairy industry in the state warrants that a proportional part of the funds appropriated for this station be used for work along dairy lines. In order, however, to make use of the money, the department must be provided with suitable quarters and facilities, and it is hoped that the appropriation for the proposed new dairy building may provide for a dairy research laboratory and a system of artificial refrigeration.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

B. S. PICKETT.

I have the honor to submit, herewith, my first annual report as Horticulturist in the New Hampshire Experiment Station. Since appointment to this position dates only from July 1st of the present year, my report is necessarily brief. The work in progress on my arrival has been continued throughout the season. The only new experiment inaugurated since July 1st, and completed, is one which I have reported briefly under the heading, "Experiment in Packing Apples."

It is proposed to reduce considerably the number of experiments conducted by the department and to concentrate attention and money on the solution of a few problems at a time.

VEGETABLE GARDENING.

The greater part of the horticultural grounds, that could be reasonably tilled at all, was devoted to the growing of vegetables. Extensive tests were made of varieties of lettuce, beans, and peas. A valuable piece of work, looking to the publication of a monograph and classification of varieties of lettuce, resulted from the first of these tests.

PLANT BREEDING WORK.

Many crosses between varieties of squashes, tomatoes and cucumbers, and some between varieties of corn, were tested. From these one valuable cucumber for greenhouse forcing has been obtained. This variety, which we call Granite State, is well established and will be offered to the public as soon as a sufficient quantity of seed has been obtained. Some excellent squash and tomato crosses also appeared, but these are not sufficiently fixed in type to be recommended as yet.

It is proposed to reduce the number of kinds of vegetables to be used in the breeding work, to concentrate time and money, on squashes and tomatoes, and to emphasize the scientific value of the records rather than the securing of new varieties of commercial importance. It is also desirable that the data already accumulated be put into shape for reference or publication; and to preserve this valuable material and carry forward the breeding projects proposed, it is necessary that a specialist be obtained who can devote his entire time to this work.

VEGETABLES UNDER GLASS.

Several vegetable crops have been grown under glass. These were, however, planted to increase the quantity of seed from certain crosses and selections of cucumbers and tomatoes, and to test some new varieties of muskmelons. Incidentally, from these tests, we found that muskmelons did not yield a profit under glass, but that cucumbers, grown at the right season, were very profitable. Two bushel boxes containing 40 and 42 cucumbers, respectively, brought $3.50 and $4.50 on the Boston market the last week in September. All other cucumbers were kept for seed but the quantity was sufficiently large to have yielded a handsome return, had they been sold in a commercial way.

FRUIT GROWING.

I found the condition of the fruit grounds generally deplorable on my arrival here in July. In the young college orchard, (Thompson orchard, as it was designated), planted 8 years ago, very few of the original trees remained, and the replants varied in age from one year to five or six years, showing that replanting had probably been necessary every year. In this orchard we have undertaken to inaugurate a system of cultivation. With considerable difficulty the ground was plowed, some of the rocks removed, and a cover crop sown. It is intended that a first-class orchard be grown where the trees now stand, with the object of demonstrating the commercial feasibility of modern methods of orchard management applied to comparatively rough New Hampshire farm lands.

Woodman Orchard. This orchard, rented for experimental purposes, under the Adams Act, having in view studies of the causes and control of the alternate bearing of Baldwin apples, has been cleaned, pruned and cultivated and given every chance to recover from the damage done by the freeze of 1906-7. The crop was very light this year, the returns being about 30 barrels. I have pleasure in reporting, however, that it is now in first-class condition and will, with a reasonably favorable season, give us good experimental material another year.

Experiment in Packing Apples. The McIntosh apples in two orchards in the town of Deerfield, were purchased with a view, to obtaining fruit to be packed in different ways. It was hoped to obtain a considerable quantity of box fruits, but an attack of late apple scab left the apples very slightly specked and not quite satisfactory for boxing. It was decided, therefore, to

pack them in barrels according to well defined grades and honest packs throughout. The No. 1 apples were shipped to three commission men in Boston. From two of these returns of $3.00 per barrel were obtained and from the third $4.00 per barrel. No. 2 apples, shipped to a fourth party, brought $1.75 and $2.00 per barrel. Two bushel boxes of perfect fruits that were obtained, were sold at $2.00 per box, or, at a rate equivalent to $6.00 per barrel. One careful spraying, late in the season, would have doubled the value of the apples in these orchards—$450 instead of $225 on the market.

Press Circular No. 1.

ALFALFA FOR NEW HAMPSHIRE.

The New Hampshire Experiment Station has had many inquiries during the past three or four years about the growing of alfalfa in the state. Up until the present time we have advised against the expenditure of very much time, labor or money by the farmers in trying to grow the plant, because in our experiments we could not secure what would be called a reasonably good stand. After repeated trials, however, in which various methods have been used, we have met with a degree of success which seems to warrant a recommendation for alfalfa to the farmers of the state. It is for the purpose of stating, in brief, our experience with the plant and giving some timely suggestions regarding it, that this is written.

Causes of Failure: The most common causes of failure are, seeding the wrong time of year; choking out by weeds or by nurse crop; poor drainage; poor seed bed; inferior seed; unfertile soil and a lack of lime.

Time of Seeding: In our earlier attempts we plowed the ground as early as possible in the spring, and after thorough harrowing sowed the seed with oats or barley and covered it with a weeder. Failing to secure a stand, we began a series of later seedings, and found them much better. Seed sown from the 20th of July to the 10th of August gave a good stand in every case, other things being equal. This date is early enough for the plants to get a good start and become well rooted before winter sets in.

Choking Out by Weeds or Nurse Crop: Our greatest difficulty with all the early seedings and to a slight extent, with the later, was the choking out of the tender plants by the more rapidly growing nurse crop, or, when no nurse crop was used, by the weeds. By seeding about August first, just after a rain, if possible, the weeds are not likely to give much trouble, and the alfalfa will make a quick growth. It is best to sow the seed on ground which is practically free from weeds, preferably on that which has been cultivated for several seasons previously. As regards the nurse crop, it may be said that we have found it of no advantage for the early seeding, and for the late it is not necessary.

Drainage: Alfalfa is naturally a deep-rooted crop and for that reason requires a deep, well-drained soil. If the natural drainage is not good the land should be tiled. It is a waste of time and money to try to grow alfalfa on wet land or on that

where ledges come within two or three feet of the surface. Winter killing is very apt to result if the land is not well drained.

Preparation of Seed Bed: Red clover may be sown on most any kind of a seed bed, but alfalfa must have one carefully prepared. There are many ways to do this, but the method we are now using, and would recommend, is as follows: If a stubble field, manure and plow about June first. Harrow every week or ten days until the date of seeding. The harrowing will keep all weeds in check and will give a well-firmed seed bed with a loose, finely pulverized mulch. By keeping the land clean and stirred, the nitrates will develop rapidly and will be ready for use by the plant when it begins its growth. If a pasture or hay field is to be seeded, apply a liberal coating of manure and plow just as soon as the hay can be cut. Then disk harrow, roll and harrow again until the ground is thoroughly pulverized. Some chemical fertilizer, especially nitrogen, may be used in this case to supplement that removed by the hay or grass.

Kind of Soil: Our experience indicates that the kind of soil is immaterial, provided it is well drained, fertile and free from weeds. The ends of our alfalfa strip are heavy clay, the middle is sandy loam and between the two loam. The alfalfa this year has been equally good on all three types of soil.

Kind of Seed: Too much emphasis cannot be placed upon securing good seed. It is always best to buy by samples and then make a germination test and an inspection for weed seeds, before purchasing in bulk. If you can not make the tests yourself, send them to the Experiment Station and we will make them for you. Good seed should be plump, free from weeds, brown or shrunken seed, and of a greenish-yellow color. Northern or northwestern grown seed is best for this latitude because it will withstand the climate better.

Liming: Alfalfa will not grow in a sour soil, and if there is any doubt about the soil being sour, it is best to use lime. This may be applied at the rate of 1000 to 2000 lbs. per acre, preferably a month, or more, before the seed is sown. It is immaterial in what form the lime is applied, although the ready prepared agricultural lime is the easiest of applicaton.

Innoculation of Soil: It is a generally accepted principle that alfalfa will not grow where the proper organisms are lacking in the soil. The presence of these germs is shown by the little nodules on the roots. In many cases enough of

the germs are sown with the seed to make the inoculation, but the most certain method is to inoculate with soil from an old alfalfa field or from a patch of sweet clover. The soil may be purchased from various alfalfa growers and scattered at the rate of 100 to 200 lbs, per acre.

Sowing the Seed: The seed may be sown broadcast, either by hand or with a seeder, at the rate of 15 to 25 lbs. per acre. It should be covered lightly with a weeder or spike-tooth harrow. Roll the ground just before seeding rather than after.

Cutting and Making: If the seed is sown about August first the plants will attain a height of 12 to 15 inches and the roots about the same length, before freezing down. The plants should not be cut off in the fall unless the weeds threaten, and then all trash should be raked off as the young plants are very easily smothered. Cut the alfalfa the next season as soon as one-fourth of the plants have blossomed. When the hay has wilted, cock and allow to cure. Handle carefully to preserve the leaves, since they are as valuable for feed as wheat bran. In about six weeks after the first cutting, a second may be made, and if the season is favorable a third cutting may be obtained. On July 4 we cut our patch the first time and secured 1.87 tons of hay per acre. With two more cuttings we expect to secure a total of at least 3.5 tons.

F. W. TAYLOR,
Agriculturalist.

July, 1907.

Press Circular No. 2.

SPRAYING FOR THE BROWN TAIL MOTH AND ORCHARD CATERPILLARS.

Inquiries frequently come to this office as to whether the young caterpillars of the brown-tail moth after they hatch from the eggs early in August may not be killed by spraying the foliage of the affected trees and thus prevent the formation of the winter webs. As the eggs are now on the trees and are just hatching, it seems opportune to call attention to the fact that the brown-tail moth may be very satisfactorily controlled in orchards by spraying at this time. Not only the brown-tail moth, but numerous other caterpillars commence to attack the foliage of the apple orchard early in August.

Among these may be mentioned the fall web-worm, a hairy caterpillar which spins its web over the foliage eaten; the yellow-necked apple caterpillar, a black larva with yellowish stripes and yellow collar or neck; and the red-humped apple

caterpillar, which is known by the prominent red hump bearing black spines, just back of the head. The yellow-necked and red-humped apple caterpillars are readily recognized by the fact that the eggs are laid on the tip of the twigs or limbs, and the caterpillars defoliate the twigs from the tip inward and usually feed in colonies. All of these caterpillars may be largely controlled by spraying during the first week of August with the arsenical poisons. Of these the arsenate of lead is the best insecticide, for the reason that it adheres best to the foliage and is not easily washed off by rain. It should be used at the rate of 5 lbs. to the barrel, and can be secured of any large seedsman or agricultural warehouse. It should be kept in stock by a local merchant in every town, as it is now coming into very general use for foliage insects. Paris green at the rate of 1-3 lb. to the barrel of water, to which should be added a pound or two of freshly-slaked stone lime, will also be effective, but it is more readily washed off by rain. Paris green should never be sprayed without adding the fresh-slaked stone lime to take up the free arsenic, as, otherwise, a burning of the foliage may occur from the soluble arsenic.

The spray should be applied very thoroughly to all parts of the trees, spraying from below and above, so as to reach both surfaces of the foliage. To reach most of the large orchard trees it is desirable to build a tower on the wagon, so that with an extension rod all parts of the tree can be sprayed, for it is well known that the brown-tail moth lays its eggs at the tips of the twigs, and the topmost branches must, therefore, be thoroughly drenched. Such a tower, and other spraying apparatus, is described in bulletin 131 of this Station, which may be had upon application.

Even with thorough spraying some of the caterpillars will escape, and there will be a few brown-tail nests, but with thorough work the number of caterpillars can be so reduced that there will be but few of the winter nests to prune. Spraying will be of little value after the latter part of August, as the young brown-tail caterpillars commence to spin up their winter webs by the latter part of the month or the first of September.

E. Dwight Sanderson,
Entomologist.

Aug. 2, 1907.

PRESS CIRCULAR No. 3.

EARLY LAMB PRODUCTION.

The conditions afforded by New Hampshire offer an excellent opportunity for the production of early lambs for the Boston market. The demand for early, or, "hot-house" lambs, is increasing every year, and the prices paid for them should encourage our sheep raisers in this phase of the industry. The advantages of early lamb production are, first, that the lambs are prepared for market at the season when farm work is slack; second, that being necessarily housed during the period, there is no danger of their being killed by dogs, or affected by parasites; and third, that the maximum return is secured from the minimum of feed consumed. The price will depend upon the weight and quality of the lambs and the season at which they are marketted. Small lambs of a blocky shape, in extra good condition, bring more than large lambs only moderately fat. The best prices are usually obtained during the months of February and March, lambs dressing from 25 to 30 lbs., bringing from $8 to $12 per head. Through the months of April, May and June from $4 to $8 per head is obtained. Lambs are sold by the carcass until about July 1st, after which they are weighed and sold by the pound.

We have found that the early lambs shrink a little over 50 per cent. in dressing, so that they should weigh from 50 to 60 lbs. at the time of slaughter. The age required to attain this weight will depend upon the care and feeding and upon the breeding. Our best lambs have weighed 50 lbs. at the age of 10 weeks, while others have required 14 or 15 weeks.

For early lambs the breeding season should begin in August, at which time the ewes should be in good condition,—not fat but in medium flesh. The number of ewes allotted to a mature ram should not be over 50, and to a lamb ram not over 25. It is always well to give the ram a little grain such as oats and bran just before and during the breeding season. If the pasture is poor the ewes, also, should have a small allowance of grain. The proper food for pregnant ewes during the winter is clover hay and 2 or 3 lbs. of roots or a good quality of corn silage. About a month before lambing time, begin feeding grain at the rate of a handful per day, gradually increasing the amount to a pound or more per day. Weak lambs and ewes without milk at the time of parturition are frequently the result of not having the ewes prepared for the lambing season, and

the lack of succulent food and grain in their ration. The ewes should also have plenty of exercise during pregnancy.

It is also important that a ram of good breeding be used, preferably a pure-bred. The lambs are half the blood of their sire, and he should be a good one. Although grade ewes may be used successfully for early spring lambs, money put in a pure-bred ram will be well invested. After the breeding season the ram should not be allowed to run with the ewes.

The leading factors for a strong and vigorous crop of lambs are good care, proper food and plenty of exercise for the ewes, and a strong, thrifty, pure-bred animal used as a sire. If you are interested in the matter of early lambs, now is the time to think and act about it.

F. W. Taylor,
Aug. 14, 1907. Agriculturist.

PRESS CIRCULAR NO. 4.

LOW GRADE COTTON SEED MEAL.

Among the samples of cotton seed meal collected during the past season by the New Hampshire State Board of Agriculture and sent to the Agricultural Experiment Station for analysis, there were two that need especial mention because they represent a class of goods which has not been observed before in this state.

The goods were properly tagged and bore plainly printed guarantees of protein and fat as the law requires. The samples were marked, respectively, Glenwood Brand Cotton Seed Feed, Protein 22 per cent., Fat 5 per cent.; and Sea Island Cotton Seed Meal, Protein 25 per cent., Fat 6 per cent. The chemical analysis showed them to be practically equal to their claims in each constituent. Therefore, no fault could be found with them on that score.

The price of these goods, was, however, of decided interest, when compared with that of standard cotton seed meal. Eight samples of standard meal contained from 38 per cent. to 42 per cent. protein and from 8.7 per cent. to 10.5 per cent. of fat. The retail prices were $1.60 and $1.65 per 100 pounds. The Glenwood and Sea Island brands retailed for $1.50 per 100 pounds.

Crude fiber was determined in the Glenwood sample, and was found to be 21 per cent. Standard cotton seed meal varies between 5 and 7 per cent. for fibre. It is plain that the two brands in question, besides possessing but three-fifths as much protein and fat, contain about three times as much indigestible

matter as standard meal, while they are retailed at nine-tenths the price of the best. Or, to put it in another way, when standard meal containing 39 per cent. protein and 9 per cent. fat sold for $1.60 per 100 pounds, one pound of those nutrients cost three and one-third cents, while in the Glenwood brand, containing 22 per cent. protein and 5 per cent. fat, at $1.50 per 100 pounds, a pound of those nutrients cost five and one half cents. These low grade materials cost too much to be economical.

Another sample of cotton seed meal among those collected in the inspection, requires notice because it was a positive fraud. It bore the tag and guarantee of a standard article and was retailed at the usual price of $1.60 per 100 pounds. The meal was even poorer than the Glenwood and Sea Island. The analysis revealed 19 per cent. protein, 5.5 per cent. fat and 22 per cent. fibre. Since cotton seed hulls contain over 40 per cent. fiber, this meal must have had about two-fifths of its weight made up of hulls, instead of being a pure meal. They were finely ground and not very noticeable, but imparted a brown color to the meal, and when a portion of it was placed on the surface of a glass of water, there was an immediate separation of the heavier hulls by settling. The name of the brand is withheld, since the tag may have been changed from a standard article to the inferior goods, without the manufacturer's or jobber's knowledge.

These goods are the first instances for several years of such marked departures from the old standards of cotton seed meal. Since standard meal will probably be even higher this fall and coming winter than last year, there will be an effort to push the lower grades because of the lower price. Buyers of grain should scrutinize both tags and quality keenly before completing a purchase, as it is natural to charge all that the market will bear for an inferior article even if there is no fraudulent substitution of tags or dishonest claims.

FRED W. MORSE,
Sept. 13, 1907. Chemist.

PRESS CIRCULAR NO. 5.

TO NEW HAMPSHIRE DAIRYMEN.
HERD TESTING ADVOCATED BY STATE EXPERIMENT STATION.

Average production of a dairy herd for a period of eleven years.

Year	Pounds of Milk.	Percent of Fat.	Pounds of Fat
1895	5073	3.19	161.8
1896	5994	3.18	190.6
1897	6401	3.08	197.2
1898	6504	3.25	211.4
1899	7329	3.36	246.3
1900	6124	3.48	213.1
1901	6850	3.32	227.4
1904	7950	3.39	269.5
1905	8447	3.38	285·5

It will be noticed that the increased average production in the year 1905 over the year 1899 was 67 per cent., or, 3410 lbs. of milk and 76.5 per cent., or 123.7 lbs fat. The increase in the per cent. of fat was 6 per cent., or .19. This is not an accident, but is brought about by careful selection, breeding and feeding. It is the result of making a careful study of the details of the business. Records were kept of the individual cows in the herd. The Babcock test was used to determine the per cent. of fat in each cow's milk. The poorer cows were eliminated, and the calves of only the better ones were used in building up the herd. A study of the above table speaks louder than words as to the results accomplished.

According to the last census there are in New Hampshire 129,900 cows. An increase of one pound of butter fat per cow, worth 30 cents, would add $38,970 to the value of the dairy products in this state, not counting the value of the skim milk, which, at 25 cents a 100 lbs. would be $8,020. An increase of 25 lbs. of milk per cow, if the milk was sold at 30 cents a can, would add $52,662 to the present value of our dairy products. When, noticing in the table above that the year 1896 shows an increase of 921 lbs. of milk and 28.6 lbs. fat per cow over the previous year, one can hardly realize the possibilities of this work, both to the individuals and the state. It is better to increase the profits in dairying by cheapening the production of milk through a system of records of the individual cows, than to depend upon higher prices. Prices will always fluctuate, while an improvement in the herd is more apt to continue to increase, rather than to fluctuate.

There is no way in which the farmers of New Hampshire can further their interest so greatly as by systematic improvement of the dairy herd. People, as a rule, are in the dairy business

for the sake of making money. If that is true why not weigh and test the milk of the individual cows in the herd, which is the only sure way to determine their value.

At present there is an increased interest in the keeping of records and testing of cows, both in New Hampshire and other states. In order to help in the advancement of this work the New Hampshire Experiment Station offers to test, free of charge, a limited number of dairy herds. This is an opportunity which ought to be welcomed by every farmer who keeps cows. Full particulars regarding this work can be had by mailing a card to the New Hampshire Experiment Station, Dairy Dept., Durham, N. H., stating the number of cows in your herd. Do it now.

FRED RASMUSSEN,
Dairyman.

PRESS CIRCULAR NO. 6.

POULTRY MANURE.

From time to time questions regarding poultry manure are received, and they include such topics as its preservation, value, use and so forth. Just now, at the beginning of the winter season, the preservation is of first importance.

As is well known, when the poultry droppings accumulate under the roosts and when they are left in barrels, there is a strong odor of ammonia noticeable. The development of such an odor is a sure sign that gaseous ammonia is escaping into the air to be lost for the present. How to prevent such a loss is to prevent the development of the odor. Several chemicals of more or less fertilizing value in themselves, may be added to the droppings from time to time with good effect, both in stopping waste and in making the atmosphere of the hen-house more wholesome.

The best materials for this purpose are gypsum or land plaster, acid phosphate, and kainit, a cheap potash salt. Each of these chemicals has the power of forming new compounds with the ammonia as fast as it is set free from the original combination. Wood ashes and slaked lime should never be used because they cannot combine with ammonia while they do force it out of its compounds and take its place. Plaster is apt to produce a dry, lumpy mixture when used in large enough quantities to arrest the ammonia, while kainit and acid phosphate produce the opposite effect of a moist, sticky mass.

In Bulletin 98 of the Maine Experiment Station, is described an experiment in which sawdust was used in addition to the chemicals. By this addition of an absorbent, the kainit and acid phosphate could then be used with excellent results.

Using their results as a basis for calculation, the weekly droppings of a flock of twenty-five hens, when scraped from the roosting platforms, should be mixed with about eight pounds of kainit or acid phosphate and a half peck of sawdust. If one desires a balanced fertilizer for corn and other hoed crops, a mixture of equal parts of kainit and acid phosphate could be used instead of either alone.

Good dry meadow muck, or peat, would be equally as good as sawdust, if not better, to use as an absorbent.

In the experiment mentioned, more than half of the ammonia was lost in hen manure without chemicals, when compared with that which had been mixed with them.

Fresh poultry manure at the present values of fertilizers would be worth sixty cents per hundred pounds. Figures from different experiment stations would give the product of twenty-five hens for the winter season of six months, as three hundred and seventy-five pounds from the roost droppings only.

Poultry manure is especially adapted as a top dressing for grass because of its high content of nitrogen in the form of ammonia compounds, which are nearly as quick in their effect as nitrate of soda. A ton of the manure preserved with sawdust and chemicals, would be sufficient for an acre, when compared with a chemical formula for top dressing.

On the same basis of comparison, one hundred fowls running at large on an acre, should in a summer season of six months have added to its fertility the equivalent of at least two hundred pounds of sulphate ammonia, one hundred pounds of high grade acid phosphate and sixty pounds of kainit.

FRED W. MORSE,
Dec. 6, 1907. Chemist.

PRESS CIRCULAR NO. 7.

GOOD GRASS SEED.

All farmers are troubled more or less with weeds, and much extra labor is required every year on the farm on account of them. When a meadow or pasture becomes too weedy it is plowed up and planted for several seasons with some cultivated crop in order to get the weeds killed out before again seeding down. In many cases, contrary to expectations, the newly

seeded field is as weedy, or, weedier, than it was before, and we wonder how it all happened. The fact of the matter is that we have sown the weeds with our grass seed and did not know it. Again, we often get a poor stand of grass and for want of a better reason ascribe it to dry weather or bad luck, while the real trouble has been that the seeds have had little or no vitality. It frequently happens that dealers will have a supply of old seed left over from the previous year, and in order to dispose of it will mix it with the new seed. Since the vitality of seeds rapidly decreases with their age, the result is a mixture with a low germination test, and when the process is repeated for several years an exceedingly bad lot of seed is obtained.

It is a notorious fact that much of the grass seed offered for sale is of poor quality, both as regards its purity and germination. Some preliminary tests made here at the college last spring showed certain commercial samples of seed corn to have a vitality of less than 75 per cent.; vetch, 34 per cent.; rape, 54 per cent.; timothy, 20 per cent.; and red top, 6 per cent. In the various samples of grass seed inspected were found all sorts of impurities, including dirt, sand, hulls, chaff, weed seeds and other grass seeds some of which were not harmless but yet constituting an impurity. Among the most noxious and injurious weed seeds found were the following: Bitter dock, Canada thistle, crab grass, goosefoot, green foxtail, lady's thumb, rib grass, plantain, sheep sorrel, yellow daisy and yellow foxtail.

While the purity test is not so easy for the average farmer to make, a sufficiently accurate germination test can be made by most anyone. The simplest way of doing this is to count out 200 seeds and place them between sheets of blotting paper, which are kept moist and in a warm room for five or six days. To detirmine whether the seed contains any considerable amount of impurities it may be spread on a sheet of paper or a white plate, and with a little practice one will soon be able to detect the more common kinds of weed seeds and to estimate the amount of them in a given sample under test.

Some states have laws regulating the inspection and sale of seeds so that the farmer is protected from fraud, either intentionally or otherwise perpetrated. In the absence of such a law in this state the Experiment Station is planning to make a limited number of purity and germination tests of grass and forage crop seeds for farmers and dealers desiring them, free of charge. Farmers buying seeds should either insist on a guarantee of

purity and vitality or else buy only on the basis of a sample submitted and tested by a competent person.

All farmers and seed dealers, who wish to take advantage of this opportunity to have seeds tested, will make request to the Experiment Station for printed directions in regard to taking the samples and the amounts of seed necessary for a test.

F. W. Taylor,
Jan. 3, 1908. Agriculturist.

Press Circular No. 8.

SOME POINTS ABOUT FERTILIZERS.

This article aims to answer in a brief way the question commonly asked about fertilizers:

The most economical goods are the high grade chemicals and mixed fertilizers. It costs no more to handle a hundred pounds of a high grade material than the same weight of low grade, and the freight is no more on it. Ten dollars will go further in the purchase of the high grade goods because the nitrogen, phosphoric acid and potash cost less per pound. For example, a high grade potato fertilizer containing 3.3 per cent. nitrogen 8 per cent available phosphoric acid and 7 per cent potash, sells this year for $39 per ton, and another potato fertilizer containing 2.1 per cent nitrogen, 8 per cent phosphoric acid and 4 per cent potash sells for $32 per ton. The higher-priced one contains $5.00 more value in nitrogen and $4.00 more value in potash or a total of $9.00 greater value.

The most common method aomng farmers in the use of fertilizers is to apply a few hundred pounds of the commercial stuff in the drill and to spread the manure broadcast, the object being to give the plants a quick start. With this in view, nitrogen is especially important, and 200 lbs. of the high grade fertilizer is more effective than 300 lbs. of the lower grade, both in amount of nitrogen and in availability.

Sometimes one asks about the relative merits of animal fertilizers compared with mineral fertilizers. A few words may make their differences plain. All potash comes from minerals unless some vegetable matter like cotton seed is used. Phosphoric acid soluble in water or, in the reverted form, is the same, whether obtained by treating bones, bone-black or rock phosphate with sulfuric acid. It was phosphate of lime in each original substance and becomes superphosate of lime in each case, after acid treatment. Nitrogen in nitrate of soda and sulfate of ammonia is in mineral form, and will act on

crops more quickly than nitrogen in animal matter, because the animal matter must first be destroyed and its nitrogen changed to nitrate. A good mixed fertilizer should contain both kinds of nitrogen; mineral nitrogen for the quick start in the spring, and the animal nitrogen for later effect and for keeping the different minerals from caking together after mixing is done.

There is no loss worth noting during the growing season from leaching or mineral nitrogen, since there is seldom enough rainfail to make up for the drying out of the soil at the surface. Besides the one form of nitrogen is no more likely to evaporate than the other.

It is not advisable to put on large quantities of soluble fertilizers from the standpoint of economy because the surplus phosphoric acid and potash must become slowly less soluble while the excess of nitrogen will leach away.

Chemicals or home-mixed fertilizers are to be preferred to ready-mixed fertilizers, since money goes farther in buying the former, when the amounts of actual plant food are compared. The cash saving is not large on small quantities, but it is worth while, even then to mix one's goods, because the quality of the materials is more certain to be of the best, especially in comparison with low grade mixed fertilizers.

Space does not permit several formulas, but the Agricultural Experiment Station will always respond to requests for such information, and directions for home mixing will be given in the next press bulletin.

FRED W. MORSE,
Chemist.

Feb. 6, 1908.

PRESS CIRCULAR NO. 9.

TO NEW HAMPSHIRE DAIRYMEN.
BUYING AND SELLING A COW ON ONE TEST.

One test of a cow only shows what she did at one milking, which is no indication of the ability or value of a cow.

Different conditions will cause a variation in per cent. of fat in cow's milk. In the early part of the lactation period when the cow is giving a large quantity of milk, the test is lower than in the latter part of the lactation period, when the milk flow is decreasing. The variation may range from a half up to three per cent depending upon the breed and individuality of the cow.

The per cent. of fat may also be influenced by the time between milking. In an experiment where cows were milked at

six o'clock in the morning and three in the afternoon, the average test in the afternoon was 4.6 per cent while in the morning it was 2.8 per cent. When the same cows were milked at 5.30 A. M. and 5 P. M., the fat content of the evening milk was 3.8 per cent and of the morning milk 3.18 per cent. The first milk drawn from the cow is much thinner than the last. Investigations by de Vriezes show the following results: in the first streams 1.2 per cent fat; after drawing about one-fourth the quantity of milk, 2.1 per cent fat; after drawing about three-fourths of the milk 5.2 per cent fat; in the last milk 7.1 per cent and in the very last drop of milk drawn, 10 per cent fat.

The relation between the nervous system of the cow and her powers of milk secretion is so intimate that any changes and abnormal conditions the cow experiences will have a direct influence upon the quantity and quality of the milk. Changes of food, of the time of feeding and drinking, restlessness in stable, changes in weather, etc., will tend to vary the quality and quantity of milk secreted. A cow tested by the writer under normal conditions gave milk testing about 4 per cent. Once while in heat she tested 12 per cent.

Furthermore, the value and reliability of a single test is also dependent upon the honesty and skill of the man who samples the milk. It is very essential to have the milk thoroughly mixed before the sample is taken. More conditions for, and examples of variation in cow's milk can be given, but this will illustrate the uncertainty of using the test of a single milking as a guide in the buying or in the selling of cows. To find the value of a cow it is necessary to weigh and test her milk at regular intervals during the lactation period.

A local test association will solve this problem. The Dairy Department, New Hampshire Experiment Station, will assist in organizing. Blanks for keeping daily records, and directions for weighing and sampling can be had upon application.

FRED RASMUSSEN,
Dairyman.

Mar. 27, 1908.

PRESS CIRCULAR NO. 10.

COTTON SEED MEAL AND MIXED FEED.

The Chemical Department of the New Hampshire Agricultural Experiment Station has recently completed the analyses of all brands of cotton seed meal and mixed feed licensed and sold in

the state. There were in all eight samples of cotton seed meal and eighteen of mixed feed.

Both classes of material were equal to or better than their guaranties in both protein and fat. There were no low grade mixtures of cotton seed meal and hulls found, and only one sample that was off color; but all samples were of high grade meal, and with a single exception, they were bright yellow in color and with a fresh, sweet odor.

The mixed feeds were all pure wheat products and included none of the mixtures of corn-cob meal obtained in previous years.

This absence of low grade goods in both classes is gratifying evidence of the effects of inspection and publicity, and of the desire of dealers to handle only the best materials.

The cotton seed meals bore guaranties of protein ranging from 38 to 41 per cent and they were found to contain from 40.06 per cent to 44.93 per cent. The mixed feeds were not guaranteed in a majority of cases, since there is confusion over the law, as some states exempt them when prepared from pure wheat products.

They should bear guaranties in this state, and on eight brands the claims for protein ranged from 14 to 17 per cent. The analyses of all gave a range from 15.09 per cent to 17.72 per cent.

The fat in cottonseed meals varied from 8.38 per cent to 10.77 per cent while in the mixed feeds the range was from 4.06 to 5.39.

The samples were collected early in March and prices at the time varied from $1.60 to $1.70 per 100 pounds for cottonseed meal and from $1.45 to $1.70 for mixed feed. The prevailing prices were $1.60 and $1.65 for either of the materials.

This equality in prices is of great interest in connection with economical feeding of live stock. It should be well known that the reason for exacting a printed statement of the percentages of protein and fat in commercial feeding stuffs, is that these ingredients are the most valuable portions of the grain. Yet in the face of the wide difference in printed guarantees purchasers are regularly paying as much for one as for the other.

The milch cow needs protein in her food to meet the daily drain in the milk. In cottonseed meal one buys 31 pounds of digestible protein in every hundred pound sack, while one gets but 12½ pounds in a sack of mixed feed. Furthermore, a sack of cottonseed meal is worth $1.17 for the fertilizing elements in it; and the sack of mixed feed contains but 58 cents worth of such

elements. Therefore the farmer who feeds mixed feed is paying more than twice as much for his protein and fertility as the one who uses cottonseed meal.

FRED W. MORSE,
Chemist.

May 29, 1908.

PRESS CIRCULAR NO. 11.

AN OUTBREAK OF FOREST CATERPILLARS.

For the past month serious injury to hardwood trees by caterpillars has been reported throughout the hill towns of the state south of the White Mountains. In Ossipee, Tamworth, and Sandwich several thousand acres have been denuded so the forests composed largely of maple and beech are as bare as in winter. Serious injury also occurs in Plymouth, Sanbornville, Laconia, Weare, Hancock, Sullivan, Newport and elsewhere. No injury has been observed or reported north of Intervale, nor does any injury occur in the valleys or on isolated shade trees.

This unprecedented injury is due to a green caterpillar, about one and one-half inches long when full grown, of a bright green color and marked on the back with purplish-red of variable pattern but usually consisting of an arrow-head mark about the middle of the back and minor markings toward the head and tail. The caterpillar is the larva of a native moth, *Heterocampa guttivitta* Walk. As it has never attracted attention before it has received no common name, but may well be termed the Purple-marked Forest Caterpillar. The insect has always occurred here and throughout the eastern United States, but has never done any injury. The present outbreak is, therefore, most unprecedented.

Almost all insects are prevented from increasing in abnormal numbers by their natural enemies, either parasitic insects, predaceous insects, or diseases. In the present case some of these natural enemies have been destroyed, probably by weather conditions, and the insect has, therefore, increased in abnormal numbers. Just what the most important of its natural enemies are, remains to be determined and they are being studied. It is evident that it is entirely impossble to cope with the pest upon hundreds of acres of forest land in an artificial manner. Shade trees near infected forests may be protected by spraying with arsenate of lead, three to five pounds per barrel of water, or by tying strips of sticky fly-paper or tanglefoot around the trunks and thus preventing the ascent of the caterpillars. The injury by the pest seems to be about over for this year. When full grown the caterpillar descends to the base of the tree and

there changes into a chrysalis or pupa about two inches under the surface of the leaf mold. Whether another brood of moths will emerge or not is not known, but it seems most probable that there is but one brood and that the moths will emerge next May and June. The moth is of an olive color with a wing expanse of about one and one-half inches.

The writer will be indebted to any who send him considerable numbers of the caterpillars and also for information concerning the extent and seriousness of the damage in their vicinity.

It seems doubtful whether so serious damage will occur another year, but only a better knowledge of the pest's enemies will enable to make intelligent predictions.

E. Dwight Sanderson,
August, 1908. Entomologist.

Press Circular No. 12.

KEEP THE APPLES IN A COOL PLACE.

Apple picking time will soon be here and both growers and buyers who are planning to store their fruit for advanced prices in the spring, should bear in mind the information given in Bulletin 135 of the New Hampshire Agricultural Experiment Station.

It has long been known that fruit ripens faster in a warm place than in a cool one, and this knowledge is applied in handling pears, bananas and other fruits that are picked green for long shipments.

Winter apples also undergo this ripening process, commonly called "after-ripening." The process has been shown to be accomplished by chemical changes in the constituents of the fruit-cells.

In addition to preventing decay, an important effect of cold-storage is retarding the chemical changes of after-ripening.

In the bulletin attention is called to the fact that during all this period of after-ripening, the apple is carrying on a breathing process, which is shown by the exhalation of carbonic acid gas, and which marks the progress of chemical action. The respiration must result in the destruction of the apple's own cell-contents, since there is no outside food-supply to provide material for the formation of carbonic acid in animals.

Experiments show that there is a definite rate of variation of the chemical activity as the temperature of the fruit changes. If the temperature of the fruit is raised eighteen degrees, the amount of carbonic acid given out is more than double what it is at the lower temperature.

In October, the average maximum temperature in this locality is 60 degrees, and the average minimum temperature is a little under 40 degrees. Apples in a cool cellar which can be kept at the lower temperature will then change only half as fast as those exposed to the higher one. The average daily temperature in October and early November is about 48 degrees, hence it can be seen that one month out of storage in the fall will carry the ripening process along to a stage which it would barely reach in two months of cold-storage.

It is doubtful economy to hold fine apples outside of cold storage warehouse to save a month's charges, since it should be clearly seen that these experiments show that the earlier they are put in a cool place the firmer their flesh and the better their flavor in the spring months to come.

The process of after-ripening is a complex chemical problem, but like most chemical reactions, it follows changes in temperature in accordance with well-known laws and can be retarded to the minimum at 32 degrees and quadrupled by raising the temperature to 70 degrees.

FRED W. MORSE,
Chemist.

Sept. 25, 1908.

METEOROLOGICAL RECORD

July 1, 1906, to June 30, 1908.

Durham, N. H., Latitude 43° 8′, N , Longitude 70° 56′, W.
Elevation above the sea 88 feet.

Meteorological Record: Month of July, 1906.

July, 1906.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	74	59	15	Show	ers	.44	......	....	N.	Partly cloudy..
2	78	52	16	Show	ers	.38	......	....	E.	Partly cloudy..
3	79	62	17	....	....	....	......	....	E.	Partly cloudy..
4	85	65	20	Show	ers	.60	......	....	N.	Partly cloudy..
5	72	51	21	....	....	....	......	....	N. N. E.	Partly cloudy..
6	74	45	29	....	....	....	.....	....	E.	Partly cloudy..
7	75	43	32	....	....	....	......	....	E.	Partly cloudy..
8	76	53	23	....	....	....	.....	....	E.	Partly cloudy..
9	78	53	25	8.22 a. m.	11.30 p. m.	.04	.....	....	S. E.	Cloudy ....
10	85	59	26	Show	ers	.04	......	....	S. E.	Partly cloudy..
11	80	59	21	Night	Night	.02	......	.... .	S. E.	Partly cloudy..
12	77	57	20	....	....	....	......	....	S. E.	Partly cloudy..
13	85	52	33	....	....	....	......	....	S. E.	Clear ....
14	81	53	28	....	....	....	......	....	S. E.	Partly cloudy
15	86	52	33	....	....	....	......	....	S. E.	Partly cloudy..
16	82	53	29	....	....	....	......	....	S. S. E.	Partly cloudy..
17	90	60	30	4.54 p.m.	7.40 p. m.	.97	.....	....	S. W.	Partly cloudy..
18	84	61	23	....	....	....	......	....	W.	Partly cloudy..
19	86	52	34	....	....	....	......	....	S. W.	Clear............
20	85	55	30	....	....	.... ..	......	....	S.	Partly cloudy..
21	83	66	17	Show	ers	.03	......	....	S. W.	Cloudy ....
22	90	60	30	Night	Night	.10	......	....	S. W.	Partly cloudy..
23	83	69	14	....	....	....	......	....	S. W.	Cloudy ....
24	77	67	10	....	....	....	......	....	W.	Cloudy ....
25	76	59	17	....	....	....	......	....	E.	Partly cloudy..
26	72	49	23	....	....	....	.....	....	N. E.	Partly cloudy..
27	77	58	19	8.47 p. m.	Night	.03	......	....	S. E.	Partly cloudy...
28	77	56	21	....	....	....	......	....	S. E.	Partly cloudy..
29	85	65	20	....	....	....	......	....	S.	Partly cloudy..
30	84	64	20	Show	ers	.91	......	....	S. W.	Partly cloudy..
31	82	64	18	....	....	....	......	....	E.	Partly cloudy..
Sum	2500	1774	714	....	....	3.56	......	....	....	....
Mean	80.64	57.22	23.03	....	....	....	......	....	....	....

† Including rain, hail, sleet and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 80.64; Mean minimum, 57.22; Mean, 68.93; Maximum, 90; Date, 17, 22; Minimum, 43; Date, 7; Greatest daily range, 34.

Precipitation—Total, 3.56 inches; Greatest in 24 hours, .97; Date, 17.

Number of Days—With .01 inch or more precipitation, 11; Clear, 2; Partly cloudy, 25; Cloudy, 4.

Dates of—Thunderstorms, 17, 21, 29, 31.

Meteorological Record: Month of August, 1906

August, 1906.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	75	63	12	8.57 p. m.	Night	.55	......	....	E.	Cloudy ....
2	76	56	20	....	....	....	....	....	E.	Partly cloudy..
3	73	54	19	....	....	....	......	....	S. E.	Cloudy ....
4	69	62	7	Show	ers	.20	......	....	S. E.	Cloudy ....
5	90	65	25	....	....	....	......	....	S. E.	Clear...........
6	94	64	30	3.20 p. m.	3.20 p. m.	.18	......	....	S. W.	Partly cloudy..
7	85	68	17	....	....	....	......	....	N. W.	Partly cloudy..
8	77	64	13	a. m. Show	ers	.03	......	....	S. E.	Partly cloudy..
9	85	57	28	....	....	....	......	....	S. E.	Partly cloudy..
10	77	52	25	Drizzle 4.15	-4.30 p. m.	....	......	....	S. E.	Partly cloudy..
11	85	63	22	Show	ers	.12	......	....	S. E.	Partly cloudy..
12	83	61	22	....	....	....	......	....	N. W.	Partly cloudy..
13	75	45	30	....	....	....	......	....	W.	Partly cloudy..
14	75	52	23	....	....	....	....	....	N. W.	Partly cloudy..
15	74	45	29	....	....	....	......	....	W.	Partly cloudy..
16	79	46	33	....	....	....	......	....	W.	Partly cloudy..
17	84	50	34	....	....	....	......	....	W.	Clear.. ....
18	94	56	38	....	....	....	......	....	S. W. W.	Clear...........
19	96	76	20	....	....	....	....	....	S. S. W.	Clear...........
20	91	69	22	....	....	....	......	....	S. W.	Cloudy ....
21	85	69	16	12 m.	12.30 p. m.	.46	......	....	S. S. W.	Cloudy ....
22	89	68	21	....	....	....	......	....	S. S. W.	Cloudy ....
23	91	68	23	7.05 p. m.	8 p. m.	.58	......	....	S. W.	Partly cloudy..
24	74	58	16	Ni	ght	.4	.....	....	N. E.	Partly cloudy..
25	73	46	27	....	....	....	......	....	E.	Partly cloudy..
26	77	57	20	....	....	....	......	....	S. E.	Cloudy ....
27	85	62	23	7. p. m.	8 p. m.	.2	......	....	S. E.	Cloudy ....
28	80	62	18	....	....	....	......	....	S.	Cloudy ....
29	77	42	35	....	....	....	....	....	S.	Partly cloudy..
30	87	55	32	....	....	....	......	....	S. S. W.	Partly cloudy..
31	79	67	12	Ni	ght	.15	......	....	S. S. W.	Partly cloudy..
Sum	2534	1822	712	....	....	2.87	......	....	....	....
Mean	81.74	58.77	22.97	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 81.74; Mean minimum, 58.77; Mean, 70.25; Maximum, 96; Date, 19; Minimum, 42; Date, 29; Greatest daily range, 38.

Precipitation—Total, 2.87 inches; Greatest in 24 hours, .58; Date, 23.

Number of Days—With .01 inch or more precipitation, 10; Clear, 4; Partly cloudy, 18; Cloudy, 9.

Meteorological Record: Month of September, 1906.

September, 1906.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	69	54	15	....	....	....	......	....	W.	Partly cloudy..
2	75	40	35	....	....	....	......	....	S. S. W.	Partly cloudy..
3	80	62	18	Show	ers	.35	......	....	N. W.	Partly cloudy..
4	65	49	16	....	....	....	......	....	S. E.	Partly cloudy..
5	74	37	37	....	....	....	......	....	S. S. E.	Partly cloudy..
6	89	40	49	....	....	....	......	....	S. W.	Partly cloudy..
7	85	52	33	....	....	....	......	....	S. W.	Partly cloudy..
8	73	53	20	....	....	....	......	....	S. E.	Partly cloudy..
9	88	46	42	....	....	....	......	....	S. S. E.	Partly cloudy..
10	76	51	25	....	....	....	......	....	S. E.	Clear............
11	79	45	34	....	....	....	......	....	S. S. E.	Partly cloudy..
12	84	52	32	....	....	....	......	....	S. S. W.	Partly cloudy..
13	83	62	21	....	....	....	......	....	S. S. W.	Cloudy ....
14	75	58	17	....	....	....	......	....	N. N. W.	Partly cloudy..
15	65	45	20	....	....	....	......	....	N. E.	Clear............
16	64	39	25	....	....	....	......	....	S. E.	Clear............
17	79	36	43	....	....	....	......	....	S. W.	Clear............
18	90	57	33	Night	6.55 a. m.	.01	......	....	N.	Partly cloudy..
19	88	59	29	....	....	....	......	....	E. S. E.	Clear............
20	73	58	15	....	....	....	......	....	E. S. E.	Partly cloudy..
21	85	59	26	....	....	....	......	....	E. S. E.	Partly cloudy..
22	70	57	13	12 m.	6 p. m.	.26	......	....	S. E.	Cloudy ....
23	78	57	21	Night	Night	.16	......	....	N. W.	Partly cloudy..
24	64	41	23	....	....	....	......	....	N. N. W.	Partly cloudy..
25	68	29	39	....	....	....	......	....	S.	Clear.. ....
26	72	39	33	....	....	....	......	....	S. W.	Clear............
27	68	53	15	Night	2.30	.34	......	....	N. N. W.	Cloudy ....
28	71	44	27	....	....	....	......	....	E. S. E.	Partly cloudy..
29	68	36	32	....	....	....	......	....	S. S. W.	Partly cloudy..
30	55	46	9	Night	Night	.02	......	....	N. W.	Partly cloudy..
31	......	......	......	....	....	....	......	....	....	....
Sum	2255	1456	799	....	....	1.14	......	....	....	....
Mean	75.16	48.53	26.63	.. ..	....		......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

TEMPERATURE—Mean maximum, 75.16; Mean minimum, 48.53; Mean, 61.85; Maximum, 90; Date, 18; Minimum, 29; Date, 25; Greatest daily range, 49.

PRECIPITATION—Total, 1.14 inches; Greatest in 24 hours, .35; Date, 3.

NUMBER OF DAYS—With .01 inch or more precipitation. 6; Clear, 7; Partly cloudy, 20; Cloudy, 3.

DATES OF Killing frost, 25.

Meteorological Record: Month of October, 1906.

October, 1906.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	64	29	35	....	....	....	......	....	S.	Partly cloudy..
2	69	34	35	....	....	....	......	....	S. S. E.	Partly cloudy..
3	66	33	33	....	....	....	......	....	S. E.	Partly cloudy..
4	67	43	24	....	....	....	......	....	S. S. E.	Partly cloudy..
5	70	42	28	....	....	....	......	....	S.	Partly cloudy..
6	71	46	25	Night also 4.30 p. m.	———	.31	......	....	S.	Cloudy ....
7	65	44	21	———	Night	.02	......	....	W.	Partly cloudy..
8	61	33	28	....	....	....	......	....	S. S. E.	Clear...........
9	71	38	33	5.30 p. m.	———	.01	......	....	S. S. E.	Partly cloudy..
10	62	44	18	———	Night	.91	......	....	N. W.	Partly cloudy..
11	53	30	23	....	....	....	......	....	S. W.	Partly cloudy..
12	51	31	20	....	....	....	......	....	N. W.	Clear...........
13	54	24	30	....	....	....	......	....	S. S. E.	Clear...........
14	61	24	37	....	....	....	......	....	S. S. E.	Partly cloudy..
15	67	30	37	....	....	....	......	....	S. S. E.	Partly cloudy..
16	60	36	24	....	....	....	......	....	E.	Partly cloudy..
17	54	42	12	....	....	....	......	....	E.	Partly cloudy..
18	54	43	11	....	....	....	......	....	E.	Partly cloudy..
19	62	47	15	7.20 p. m.	7.40 p. m.	.01	......	....	S. S. E.	Partly cloudy..
20	63	55	8	9.30 a. m.	2.40 p. m.	.28	......	....	N. E.	Cloudy ....
21	58	49	9	Night	Night	.01	......	....	N. E.	Partly cloudy..
22	53	44	9	Night	Night	trace	......	....	N. E.	Partly cloudy..
23	67	47	20	....	....	....	......	....	N. W.	Partly cloudy..
24	55	38	17	....	....	....	......	....	S. E.	Partly cloudy..
25	64	42	22	7.15 a. m.	10.30 a. m.	.60	......	....	W. N. W.	Cloudy ....
26	61	34	27	....	....	....	......	....	W.	Partly cloudy..
27	56	32	24	....	....	....	......	....	S. E.	Cloudy ....
28	60	44	16	....	....	....	......	....	W. S. W.	Partly cloudy..
29	49	34	15	....	....	....	......	....	W.	Partly cloudy..
30	43	31	12	....	....	....	......	....	N. N. E.	Cloudy ....
31	42	33	9	Night	1.30 p. m.	.18	......	....	N. N. E.	Partly cloudy..
Sum	1853	1276	577	....	....	2.33	......	....	....	....
Mean	59.7	41.1	18.6	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 59.7; Mean minimum, 41. 1; Mean, 50.4; Maximum, 71; Date, 6 and 9; Minimum, 24; Date, 13 and 14; Greatest daily range, 37.

Precipitation—Total, 2.33 inches; Greatest in 24 hours, .91; Date, 10.

Number of Days—With .01 inch or more precipitation, 8; Clear, 3; Partly cloudy 23; Cloudy, 5.

Dates of Thunderstorms, 9.

Meteorological Record: Month of November, 1906.

November, 1906.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	42	31	11	....	....	....	......	.....	N. W.	Cloudy ....
2	42	32	10	Night	Noon	.26	.5	....	N.	Cloudy ....
3	61	31	30	....	....	....	......	....	N. W.	Partly cloudy..
4	52	32	20	....	....	....	......	....	N. N. W.	Partly cloudy..
5	56	24	32	....	....	....	......	......	N. E.	Partly cloudy..
6	51	31	20	....	....	....	......	....	N. N. W.	Partly cloudy..
7	45	32	13	....	....	....	......	....	N. W.	Clear............
8	51	30	21	....	....	....	......	....	N.	Clear............
9	45	31	14	....	....	....	......	....	N. W.	Partly cloudy..
10	50	33	17	....	....	....	......	....	N. W.	Partly cloudy..
11	39	29	10	11.30 a. m.	———	1.11	.5	.5	E.	Cloudy ....
12	35	32	3	———	4 p. m.	.20	......	....	N.	Cloudy ....
13	40	26	14	....	....	....	......	. ....	W.	Partly cloudy..
14	48	25	23	....	....	....	......	....	W. N. W.	Partly cloudy..
15	36	22	14	3.30 p. m.	———	.62	2.1	2.1	N. E.	Cloudy ....
16	36	34	2	———	Night	.02	......	2.0	N. W.	Partly cloudy..
17	45	39	6	....	....	....	......	.. ....	W. N. W.	Partly cloudy..
18	60	34	26	. . ..	....	....	......	....	W. S. W.	Cloudy ....
19	60	35	25	....	....	....	......	....	W. N. W.	Partly cloudy..
20	48	41	7	....	....	....	......	....	W. N. W.	Cloudy ....
21	45	37	8	Night also 2.45 p. m.	———	.40	......	....	N. W.	Cloudy ....
22	48	36	12	———	Night	.11	......	....	W.	Partly cloudy..
23	45	32	13	....	....	....	......	....	W. N. W.	Clear............
24	38	30	8	....	....	....	......	....	N. W.	Partly cloudy..
25	49	23	26	....	....	... .	......	....	W. N. W.	Clear............
26	46	36	10	Night	———	.02	......	....	W.	Cloudy ....
27	45	30	15	———	3.30 p. m.	.22	.5	.25	E. N. E.	Cloudy ....
28	35	26	9	Flurries	all day	.12	1.6	1.9	E. N. E.	Cloudy ....
29	31	20	11	Night	Night	.03	......	1.7	N. W.	Partly cloudy..
30	34	18	16	....	....	....	......	1.7	W.	Partly cloudy..
31	......	......	......	....	....	....	......	....	....	....
Sum	1238	912	326	....	....	3.11	5.2	....	....	....
Mean	41.26	30.4	10.86	....	....	....	.. ...	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 41.26; Mean minimum, 30.4; Mean, 35.83; Maximum, 61; Date, 3; Minimum, 18; Date, 30; Greatest daily range, 32, on 5th.

Precipitation—Total, 3.11 inches; Greatest in 24 hours, 1.11; Date, 11.

Snow—Total fall, 5.2 inches; on ground, 15th, 2.1 inches; at end of month, 1.7 inches.

Number of Days—With .01 inch or more precipitation, 11; Clear, 4; Partly cloudy, 15 Cloudy, 11.

Meteorological Record: Month of December, 1906.

December, 1906.	Temperature. Maximum.	Temperature. Minimum.	Temperature. Range.	Precipitation. Time of beginning.	Precipitation. Time of ending.	Precipitation. †Amount.	Precipitation. Snowfall in inches.	Precipitation. Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	41	24	17	...	...	...	...	...	N. W.	Partly cloudy
2	33	6	27	...	...	...	...	...	N. W.	Clear
3	26	5	21	Night	9.30 a. m.	.10	1.5	1.5	N.	Partly cloudy
4	19	4	15	...	...	...	...	1.0	W.	Clear
5	30	1	29	...	...	...	...	1.0	W.	Partly cloudy
6	37	19	18	Night	8.00 p. m.	.71	2.5	1.8	N.	Cloudy
7	37	—3	40	...	...	...	...	1.8	N. W.	Partly cloudy
8	5	—6	11	...	...	...	...	1.8	W. N. W.	Partly cloudy
9	10	3	7	Night	Night	.01	...	1.8	N. W.	Cloudy
10	27	13	14	Night	8.00 p. m.	.45	5.0	6.3	N.	Cloudy
11	31	13	18	...	...	...	...	6.3	N.	Clear
12	25	6	19	...	...	...	...	6.3	N.	Clear
13	36	8	28	...	...	...	...	6.3	N.	Cloudy
14	35	17	18	...	...	...	...	6.3	N.	Cloudy
15	36	17	35	Night	Evening	.42	1.0	6.5	N.	Cloudy
16	40	28	12	...	...	...	...	6.5	N. W.	Clear
17	36	20	16	...	...	...	...	6.5	N. W.	Cloudy
18	31	9	22	...	...	...	...	6.5	N. N. W.	Partly cloudy
19	26	—11	37	...	...	...	...	6.5	N. N. W.	Clear
20	29	—7	36	9.30 a. m.	———	06	...	6.5	N.	Cloudy
21	39	28	11	...	...	...	...	6.3	N. E.	Cloudy
22	42	30	12	...	...	...	...	6.0	N. N. E.	Cloudy
23	44	12	32	Night	2.00 p. m.	.64	12.	18.0	N. W.	Cloudy
24	21	10	11	8.30	10.25	.24	2.	...	N. E.	Cloudy
25	26	12	14	8.35	9.40	.12	1.	...	N. N. E.	Cloudy
26	24	20	4	8.40	9.30	.12	1.	...	N. N. E.	Cloudy
27	29	23	6	...	...	...	...	...	N. N. W.	Cloudy
28	32	25	7	...	...	...	...	...	N. W.	Cloudy
29	32	25	7	...	...	...	...	...	N. N. E.	Partly cloudy
30	44	29	15	...	...	...	...	...	E. N. E.	Cloudy
31	40	15	25	8.40	———	.64	...	...	E. S. E.	Cloudy
Sum	963	394	...	...	...	3.51	26	...	...	...
Mean	31.0	12.7	...	...	...	...	...	...	...	...

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 31.0; Mean minimum, 12.7; Mean, 21.8; Maximum, 44; Date, 23 and 30; Minimum, —11; Date, 19; Greatest daily range, 40.

Precipitation—Total, 3.51 inches; Greatest in 24 hours, .71; Date, 6.

Snow—Total fall, 26 inches; on ground, 15th, 6.5 inches; at end of month, 14 inches.

Number of Days—With .01 inch or more precipitation, 11; Clear, 6; Partly cloudy, 7; Cloudy, 18.

Meteorological Record: Month of January, 1907.

January, 1907	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	47	17	30					14.0	W.N.W.	Cloudy
2	40	16	24						N.N.E.	Cloudy
3	38	13	25						S. E.	Cloudy
4	41	24	17						W.	Cloudy
5	50	22	29						W.	Cloudy
6	34	22	12						W. S. W.	Cloudy
7	50	27	23						W.	Cloudy
8	49	28	21	2.30 p. m.	——	.20		5.0	E.	Cloudy
9	39	10	29	Night		.01		5.0	W.N.W.	Cloudy
10	25	5	20					5.0	S. W.	Cloudy
11	40	23	17					5.0	W.	Partly cloudy
12	33	13	20	9.45 a. m.	——	.90	4.0	9.0	N. N. E.	Cloudy
13	33	15	18					9.0	N. E.	Partly cloudy
14	25	16	9	——	6.00 p. m.	.10	0.5	9.5	N. E.	Cloudy
15	36	12	24						N. W.	Cloudy
16	12	—6	18						N. W.	Clear
17	12	—17	29			.02	1.0	10.0	N.N.W.	Partly cloudy
18	25	3	22						N.N.W.	Cloudy
19	34	15	19	11.30		.24		7.5	N. W.	Cloudy
20	52	32	20						W.	Partly cloudy
21	39	12	27						N. N. W.	Clear
22	18	—1	19	9.30	——	.10	4.5	6.	N.N.W.	Cloudy
23	13	—4	17						N. W.	Clear
24	4	—24	28						N. W.	Clear
25	9	—6	15	Night	3.00 p. m.	.25	4.5	7.5	N. W.	Cloudy
26	18	7	11	Night	9.30	.48	6.	10.5	N.	Partly cloudy
27	19	—5	24						N. N. E.	Partly cloudy
28	26	7	19						N. W.	Clear
29	26	—5	31						N. W.	Partly cloudy
30	29	14	15						N. W.	Clear
31	17	—11	28					10.5	N. W.	Partly cloudy
Sum	933	274					20.5			
	30.1	8.8								

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

TEMPERATURE—Mean maximum, 30.1; Mean minimum, 8.8; Mean, 19.5; Maximum, 52; Date, 20; Minimum, —24; Date, 24; Greatest daily range, 31, on 29th.

PRECIPITATION—Total, 2.3 inches; Greatest in 24 hours, .9; Date, 12.

SNOW—Total, 20.5 inches; on ground 15th, 9.5 inches; at end of month, 10.5 inches.

NUMBER OF DAYS—With .01 inch or more precipitation, 9; Clear, 6; Partly cloudy, 8: Cloudy, 17.

Meteorological Record: Month of February, 1907.

February, 1907.	Temperature.			Precipitation.					Prevailing wind direction.	Character of day.
	Maximum.	Minimum.	Range.	Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.		
1	29	13	16	3.30	Night	0.10	.25	10.75	N. E.	Cloudy........
2	40	25	15	....	....	0.02	......	10.05	N. N. E.	Cloudy........
3	40	16	24	Night	Night	.02	......	10.00	W. N. W.	Clear.. ....
4	16	12	4	....	....	....	......	....	W. N. W.	Cloudy........
5	15	9	6	Night	3.00 p. m.	.34	4.	14.	N. E.	Cloudy........
6	17	2	15	....	....	....	......	14.	N. W.	Partly cloudy.
7	25	—4	29	....	....	....	......	....	S.	Clear...........
8	27	5	22	....	....	....	......	....	S.	Clear...........
9	29	4	25	....	....	....	......	....	S.	Clear...........
10	34	3	31	....	....	.08	.50	14.0	S.	Cloudy........
11	35	15	20	....	....	....	......	....	W. N. W.	Partly cloudy..
12	16	1	15	....	....	....	......	....	W. N. W.	Partly cloudy..
13	21	1	20	....	....	....	......	....	W. N. W.	Partly cloudy..
14	50	14	36	....	....	....	......	....	S. W.	Partly cloudy..
15	49	24	19	....	....	....	......	....	W. N. W.	Clear...........
16	40	20	20	....	....	....	......	....	W.	Partly cloudy..
17	36	22	14	Night	....	.42	5.0	13.	N. N. W.	Cloudy........
18	26	15	11	....	8.00 a. m.	07	1.0	14.	N.	Partly cloudy..
19	34	4	30	1.30 p. m.	———	.22	1.5	15.	E. N. E.	Partly cloudy..
20	38	21	27	7.00 p. m.	....	.06	.75	14.75	N. E.	Partly cloudy..
21	38	19	19	....	Night	.05	.50	15	N. W.	Clear...........
22	19	3	16	....	....	....	......	....	N. W.	Clear...........
23	6	0	6	....	....	....	......	....	N. W.	Clear...........
24	18	—15	33	——— p. m.	Night	....	......	....	N. W.	Partly cloudy..
25	32	11	21	Night	Night	.60	3.5	16.0	N. W.	Partly cloudy..
26	16	5	11	....	....	....	......	....	N. W.	Partly cloudy..
27	22	7	15	....	....	....	......	....	N. W.	Partly cloudy..
28	22	—11	33	....	....	....	......	12.0	S. W.	Partly cloudy..
29	......	......	....	....	....	....	......	....	....	....
30	......	......	......	....	....	....	......	....	....	....
31	......	......	......	....	....	....	......	....	....	....
Sum	784	241	......	....	....	1.98	17	....	....	....
Mean	28	8.6	......	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

TEMPERATURE—Mean maximum, 2.8; Mean minimum, 8.6; Mean, 18.3; Maximum, 50; Date. 14; Minimum, —15; Date, 24; Greatest daily range, 36, on 14th.

PRECIPITATION—Total, 1.98 inches; Greatest in 24 hours, .60; Date, 25th.

SNOW—Total fall, 17 inches; on ground, 15th, 9 inches; at end of month, 12 inches.

NUMBER OF DAYS—With .01 inch or more precipitation, 11; Clear, 8; Partly cloudy, 14; Cloudy, 6.

DATES OF—Auroras, 7, 8, 9, and 11.

Meteorological Record: Month of March, 1907.

March, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	23	0	23						S. W.	Cloudy
2	37	15	22	Night	——— a. m.			10.	W.	Partly cloudy
3	37	27	10						N. W.	Clear
4	30	12	18						N. E.	Partly cloudy
5	32	14	18						N. N. E.	Clear
6	30	22	8						N.	Clear
7	33	12	21						N. W.	Clear
8	29	6	23			Trace			S. W.	Partly cloudy
9	31	24	7						N.	Partly cloudy
10	30	10	20						S. S. E.	Partly cloudy
11	41	20	21						N. W.	Clear
12	40	15	25						S. W.	Clear
13	44	34	10			Trace			W.	Partly cloudy
14	41	34	7	Night	Noon	.15			N. N. E.	Cloudy
15	43	35	8						W.	Partly cloudy
16	45	35	10						W.	Clear
17	55	30	25						W.	Partly cloudy
18	48	27	21						N. W.	Partly cloudy
19	34	21	13	Noon	Night	.34		7	S. S. E.	Cloudy
20	37	27	10		Night a. m.	.24	6.	7	N. W.	Cloudy
21	47	24	23						W. N. W	Partly cloudy
22	45	32	13	10.00 a. m.	10.00 a. m.	Trace			S. E.	Cloudy
23	61	45	16						N.	Partly cloudy
24	48	27	21	Night	8.00. p. m	.48	5.5	5.5	N. E.	Cloudy
25	41	20	21			Trace			S. S. E.	Partly cloudy
26	54	23	31						W.	Cloudy
27	47	36	11						E. N. E.	Partly cloudy
28	57	34	23	Night	Night	.11			E. N. E.	Cloudy
29	66	42	24						S. E.	Partly cloudy
30	65	49	16						N. W.	Clear
31	56	39	17						N. W.	Partly cloudy
Sum	1327	791				1.32	11.5			
Mean	42.8	25.5								

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 42.8; Mean minimum, 25.5; Mean, 34.15; Maximum, 66; Date, 29; Minimum, 0; Date, 1; Greatest daily range, 31, on 26th.

Precipitation—Total, 1.32 inches; Greatest in 24 hours, .48; Date, 24.

Snow—Total fall, 12 inches; on ground, 15th, 8 inches; at end of month, none.

Number of Days—With .01 inch or more precipitation, 5; Clear, 8; Partly cloudy, 16; Cloudy, 7.

Meteorological Record: Month of April, 1907.

April, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of Day.
1	43	29	14	Night	———	....	......	....	N.	Cloudy ....
2	39	30	9	....	Night	.43	4	....	N.	Partly cloudy..
3	50	24	26	....	....	....	......	....	N. W.	Clear............
4	55	25	30	....	....	....	......	....	S. E.	Clear............
5	57	33	24	Night	10.30 a. m.	.15	......	....	N. W.	Partly cloudy..
6	41	32	9	....	....	....	......	....	N.	Clear............
7	36	21	15	....	....	....	......	....	S. E.	Partly cloudy..
8	36	30	6	1.00 p. m.	Night	.52	4	4	N. E.	Cloudy ....
9	33	29	4			.85	6	10	N. E.	Cloudy ....
10	37	28	9	———	8.00 p. m.	.10	3.5	12	N.	Cloudy ....
11	49	31	18	Night	9.30 a. m.	.01	......	2	N.	Partly cloudy..
12	44	24	20	....	....	....	......	....	N. W.	Partly cloudy..
13	48	36	12	9.30 a. m.	11.30 a. m.	.09	......	1	N. W.	Cloudy ....
14	54	42	12	....	....	....	......	....	N. W.	Partly cloudy..
15	46	35	11	....	....	....	......	....	N. W.	Partly cloudy..
16	54	42	12	....	....	....	......	....	S.	Partly cloudy..
17	48	32	9	Night	9.00 a. m.	.12	......	....	N. W.	Partly cloudy..
18	50	37	13	....	....	....	......	....	N. W.	Clear............
19	47	32	15	....	....	Trace	......	....	W. N. W.	Partly cloudy..
20	46	32	14	....	....	....	......	....	N. W.	Partly cloudy..
21	49	41	8	....	....	....	......	....	W.	Partly cloudy..
22	64	29	35	....	....	....	......	....	S. W.	Partly cloudy.
23	68	38	30	....	....	Trace	......	....	S.	Partly cloudy..
24	53	47	6	Night	10.00 a. m.	.53	......	....	N. W.	Partly cloudy..
25	69	35	34	....	....	....	......	....	N. E.	Partly cloudy..
26	56	43	13	....	....	Trace	......	....	N. E.	Cloudy ....
27	59	43	16	Night	Night	.09	......	....	S. S. E.	Partly cloudy..
28	51	30	21	3.00 p. m.	4.00 p. m.	.03	......	....	S. S. E.	Cloudy ....
29	57	39	18	7.00 a. m.	9.00 a. m.	.02	......	....	S. E.	Partly cloudy..
30	76	50	26	....	....	Trace	......	....	S.	Partly cloudy..
......	......	......	......	....	....	....	......	....	....	....
Sum	1515	1026	......	....	....	2.94	17.5	....	....	....
Mean	50 5	34.2	......	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 50.5; Mean minimum, 34.2; Mean, 42.3; Maximum, 76; Date, 30; Minimum, 21; Date, 7; Greatest daily range, 35.

Precipitation—Total, 2.94 inches; Greatest in 24 hours, .85; Date, 9.

Snow—Total fall, 17½ inches; on ground, 15th, 00 inches; at end of month, none.

Number of Days—With .01 inch or more precipitation, 12; Clear, 4; Partly cloudy, 19; Cloudy, 7.

Meteorological Record: Month of May, 1907.

May, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	66	50	16	....	....	....	......	....	S. E.	Partly cloudy..
2	52	37	15	....	....	....	......	....	S. E.	Clear...........
3	41	30	11	....	....	....	......	....	S. S. E.	Partly cloudy..
4	48	35	13	8.00 a. m.	3.30 p. m.	.37	......	....	S.	Cloudy ....
5	56	44	12	8.00 a. m.	....	....	......	....	W.	Clear............
6	50	33	17	6.30 p. m.	....	.05	......	....	W. N. W.	Cloudy ....
7	53	41	12	Night	Night	.02	......	....	S. S. E.	Cloudy ....
8	67	43	24	Night	Night	.03	......	....	S. S. E.	Partly cloudy..
9	53	43	10	....	....	....	......	....	S. E.	Partly cloudy..
10	70	51	19	....	....	Trace	......	....	N. W.	Partly cloudy..
11	53	38	15	Night	1.30 p. m.	.25	......	....	N. W.	Cloudy ....
12	57	45	12	Night	Night	.02	......	....	W.	Partly cloudy..
13	80	42	38	....	....	....	......	....	S. W.	Partly cloudy..
14	75	48	27	....	....	....	......	....	S.	Partly cloudy..
15	53	43	10	....	....	....	......	....	S. S. E.	Partly cloudy..
16	60	44	16	Night	———	.20	......	....	S. E.	Cloudy ....
17	65	52	13	———	9.30 a. m.	.30	......	....	W. N. W.	Cloudy ....
18	69	41	28	....	....	....	......	....	S. E.	Partly cloudy..
19	70	49	31	1.30 p. m.	2.00 p. m.	.05	......	....	N. N. E.	Partly cloudy..
20	67	48	19	....	....	....	......	....	N. W.	Partly cloudy..
21	50	43	7	....	....	....	......	....	N. W.	Partly cloudy..
22	58	36	12	....	....	....	......	....	N. W.	Partly cloudy..
23	64	33	31	....	....	....	......	....	S. E.	Partly cloudy..
24	64	38	26	....	....	....	......	....	N. W.	Partly cloudy..
25	61	38	23	....	....	....	......	....	S. S. E.	Partly cloudy..
26	58	31	27	1.00 p. m.	———	.15	......	....	....	Partly cloudy..
27	46	44	2	———	———	.30	......	....	E.	Cloudy ....
28	53	44	9	....	Night	.09	......	....	N. W.	Cloudy}.........
29	56	50	6	....	....	....	......	....	N. W.	Partly cloudy..
30	63	42	21	5.45 p. m.	———	.04	......	....	E.	Cloudy ....
31	62	47	15	....	Night	.02	......	....	S. E.	Partly cloudy..
Sum	1840	1303	......	....	....	1.89	......	....	....	....
Mean	59.3	42.0	......	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 59.3; Mean minimum, 42.0; Mean, 50.6; Maximum, 80; Date, 13; Minimum, 30; Date, 3; Greatest daily range, 38, on 13th.

Precipitation—Total, 1.89 inches; Greatest in 24 hours, .37; Date, 4.

Number of Days—With .01 inch or more precipitation, 14; Clear, 2; Partly cloudy, 20; cloudy, 9.

Dates of Killing frost, 23, 26.

Meteorological Record: Month of June, 1907.

June, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	69	37	32	....	....	....	.....	....	S.	Partly cloudy..
2	54	41	13	Noon	———	.39	......	......	E.	Cloudy ....
3	62	51	11	———	Noon	.25	.....	....	N. E.	Cloudy ....
4	63	42	21	Night	———	.35	......	....	S. E.	Cloudy ....
5	54	48	6	9.45	———	.57	......	....	S. E.	Cloudy ....
6	57	34	23	3.25	4.10	.11	.. ...	....	S. S. E.	Cloudy ....
7	65	35	30	11.00	11.30	.12	......	....	S. S. E.	Cloudy ....
8	71	39	32	———	....	....	......	....	E.	Cloudy ....
9	66	40	26	2.30	3.35	.14	......	....	E.	Cloudy ....
10	55	44	11	....	....	....	......	....	N. E.	Partly cloudy..
11	65	42	23	....	....	....	......	....	S. E.	Fair ... .
12	73	39	34	....	....	....	.....	....	E. S. E.	Fair ....
13	75	38	37	....	....	....	......	....	S. E.	Fair ....
14	76	46	30	....	....	....	......	....	S. E.	Fair ....
15	75	51	24	4.45	5.30	.01	......	....	S. E.	Fair ....
16	82	46	36	....	....	....	......	....	Variable	Fair ....
17	80	50	30	....	....	....	......	....	W. N. W.	Fair ....
18	94	62	32	....	....	....	......	....	S.	Fair ....
19	80	60	20	....	....	....	......	....	S. S. E.	Fair ....
20	75	58	17	....	....	....	......	......	S. E.	Partly cloudy..
21	84	62	22	....	....	....	.....	....	Variable	Fair ....
22	84	56	28	....	....	....	......	....	Variable	Fair ....
23	86	54	32	....	....	....	......	....	S. E.	Fair ....
24	91	60	31	....	....	....	......	....	Variable	Fair ....
25	93	65	28	5.45	7.15	.09	......	......	S.	Fair ....
26	77	61	16	6.00	Night	.10	......	....	S.	Fair ....
27	73	65	8	....	....	....	......	....	W. N. W.	Cloudy ....
28	85	59	36	....	....	....	......	....	N. W.	Partly cloudy..
29	79	56	23	....	....	....	......	....	E.	Cloudy ....
30	73	55	18	8.00 p. m.	9.00 a. m.	.49	......	....	E.	Cloudy ....
Sum	2316	1386	750	....	....	2.62	......	..... .	....	....
Mean	77.2	46.2	25	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 77.2; Mean minimum, 46.2; Mean, 61.1; Maximum, 94; Date, 18; Minimum, 34; Date, 6; Greatest daily range, 37.

Precipitation—Total, 2.62 inches; Greatest in 24 hours, .57; Date, 5.

Number of Days—With .01 inch or more precipitation, 11; Clear, 15; Partly cloudy, 4; Cloudy, 11.

Dates of—Thunderstorms, 25, 26.

Meteorological Record: Month of July, 1907.

July, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	80	69	11							
2	80	65	15						S. W.	Cloudy
3	73	60	13						S. S. E.	Partly cloudy
4	80	49	31						S.	Fair
5	83	49	34						S. E.	Clear
6	82	53	29	9.00 p. m.					S. E.	Clear
7	70	62	8	4.30, 5.30	8.00 a. m.	.77			E.	Cloudy
8	79	60	19						S. E.	Clear
9	82	62	20	11.30—	1.00	.11			Variable	Partly cloudy
10	78	61	17						W.	Clear
11	76	55	21	2.30	——				E.	Cloudy
12	66	56	10		12.30 p. m.	.85			E.	Cloudy
13	80	59	21						W.	Clear
14	79	52	27						S. E.	Clear
15	76	55	21						S. E.	Clear
16	82	54	28						S. E.	Cloudy
17	89	60	29	5.30, 6.10	6.00, 8.00	.14			S.	Clear
18	92	69	23						W.	Clear
19	89	66	21						W.	Clear
20	86	61	25	Night	Night	.65			W.	Clear
21	78	62	16	——					N. W.	Clear
22	85	55	30	4.30	7.00	.10			W.	Partly cloudy
23	80	61	19	Morn	ing	.01			W.	Partly cloudy
24	69	59	10	Ni	ght	.09			E.	Partly cloudy
25	79	57	22						W.	Partly cloudy
26	81	61	20	7.50—	—11 a. m.	.20			W.	Cloudy
27	75	60	15						W.	Partly cloudy
28	82	63	18						W.	Clear
29	88	60	28						S. W.	Clear
30	73	60	13						E.	Cloudy
31	82	59	23						W.	Clear
Sum	2521	1794	648			2.82				
Mean	81.	57.9	20.9							

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

TEMPERATURE—Mean maximum, 81; Mean minimum, 58; Mean, 69.5; Maximum, 92; Date, 18; Minimum, 49; Date, 4, 5; Greatest daily range, 30.

PRECIPITATION—Total, 2.82 inches; Greatest in 24 hours, .85; Date, 12.

NUMBER OF DAYS—With .01 inch or more precipitation, 9; Clear, 15; Partly cloudy, 9; Cloudy, 5.

DATES OF—Thunderstorms, 7, 17, 20.

Meteorological Record: Month of August, 1907.

August, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	86	55	21	4.00	About 6.00	.01	......	....	W.	Partly cloudy..
2	76	60	16	....	....	....	......	....	E.	Partly cloudy..
3	81	60	21	....	....	....	......	....	W.	Clear...........
4	70	56	14	7.00	9.30	.20	......	....	N. W.	Partly cloudy..
5	79	53	28	....	....	....	......	....	....	Clear........ ..
6	74	55	19	8.00	10.00	.10	......	....	S. E.	Partly cloudy..
7	82	54	28	....	....	....	......	....	S. E.	Partly cloudy..
8	85	58	27	....	....	....	......	....	S. E.	Clear............
9	74	54	20	....	....	....	......	....	S.	Clear............
10	91	55	36	....	....	....	......	....	S.	Clear.. ....
11	95	57	38	....	....	....	......	....	S.	Clear............
12	94	65	29	....	....	....	......	....	S.	Clear............
13	86	65	21	....	....	....	......	....	S.	Clear............
14	76	60	16	....	....	....	......	....	W.	Clear............
15	80	45	35	....	....	....	......	....	S. W.	Clear.......... .
16	81	39	42	....	....	....	......	....	S. W.	Partly cloudy..
17	74	60	14	10.00	11.30	.70	......	....	S.	Partly cloudy..
18	66	70	16	Ni	ght	.05	......	....	S. W.	Clear............
19	80	39	41	....	....	....	......	....	S. W.	Clear............
20	89	45	44	....	....	....	......	....	S. W.	Clear............
21	76	55	21	10.30	5.00	.30	......	....	N. E.	Cloudy ....
22	71	54	17	....	....	....	......	....	....	....
23	70	60	10	....	....	....	......	....	N. E.	Cloudy ....
24	71	41	30	6.10	7.30	.09	......	....	S. S. E.	Cloudy ....
25	69	49	20	....	....	....	......	....	N. N. W.	Cloudy . ...
26	76	56	20	....	....	....	......	....	N. W.	Cloudy ....
27	75	45	30	Ni	ght	.09	......	....	W.	Clear............
28	72	50	22	....	....	....	......	....	W.	Clear............
29	72	48	24	....	....	....	......	....	N. W.	Partly cloudy..
30	72	52	20	....	....	....	......	....	N. W.	Partly cloudy..
31	70	52	18	....	....	....	.....	....	N. E.	Partly cloudy..
Sum	2533	1667	756	....	....	1.54	......	....	....	....
Mean	81	55	25	....	....	....	......	....	....	....

† Including rain, hail, sleet and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 81; Mean minimum, 55; Mean, 63; Maximum, 95; Date, 11; Minimum, 39; Date, 16; Greatest daily range, 44.

Precipitation—Total, 1.54 inches; Greatest in 24 hours, .70; Date, 17.

Number of Days—With .01 inch or more precipitation, 8; Clear, 15; Partly cloudy, 11; Cloudy, 5.

Meteorological Record: Month of September, 1907.

September, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	75	45	30	....	....	....	......	......	S. E.	Partly cloudy..
2	65	44	21	12.00	....	....	......	......	S- E.	Cloudy.........
3	63	48	15	....	6.00 a. m.	1.97	....	......	S. E.	Cloudy.........
4	65	55	10	....	....	....	......	......	S. E.	Cloudy.........
5	78	56	22	....	....	.07	......	......	S. S. W.	Cloudy.........
6	78	60	18	....	....	....	......	......	W.	Partly cloudy..
7	76	61	15	....	....	....	......	......	W. N. W.	Partly cloudy..
8	68	53	15	....	....	.08	......	......	W.	Partly cloudy..
9	65	60	5	....	....	....	......	......	E.	Partly cloudy..
10	62	58	4	....	....	.03	......	......	E.	Partly cloudy..
11	73	59	14	....	....	.05	......	......	E.	Partly cloudy.
12	76	61	15	....	....	.20	......	......	S. S. W.	Partly cloudy..
13	77	67	10	....	....	....	......	......	W. N. W.	Partly cloudy..
14	68	59	9	....	....	....	......	......	S. S. E.	Clear...........
15	84	50	34	....	....	....	......	......	S. W.	Clear...........
16	77	59	18	....	....	....	......	......	N. W.	Partly cloudy..
17	79	60	19	....	....	....	......	......	N. W.	Partly cloudy..
18	62	44	18	....	....	....	......	......	S. E.	Clear...........
19	66	33	33	....	....	....	......	......	S. S. E-	Partly cloudy..
20	75	50	25	....	....	....	......	......	S. S. E.	Clear...........
21	82	62	20	Ni	ght	.10	......	......	S. S. E.	Partly cloudy..
22	77	63	14	....	....	....	......	......	W.	Partly cloudy..
23	64	51	13	——	——	1 95	......	......	N. N. W.	Cloudy.........
24	79	54	25	——	——	.97	......	......	N. W.	Cloudy.........
25	63	52	11	....	....	....	......	......	W. N. W.	Clear...........
26	55	42	13	....	....	....	......	......	W. N. W.	Partly cloudy..
27	63	35	28	....	....	....	......	......	W. N. W.	Partly cloudy..
28	64	52	22	....	....	....	......	......	N. E.	Cloudy.........
29	54	40	14	....	....	2.90	......	......	N. N. E.	Cloudy ....
30	55	42	13	....	....	.08	......	......	N. W.	Partly cloudy..
Sum	2088	1575	......	....	....	8.40	......	......	....	....
Mean	69.6	52.5	......	....	....	....	......	......	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 69.6; Mean minimum, 52.5; Mean, 61; Maximum, 84; Date, 15; Minimum, 33; Date, 19; Greatest daily range, 34, on 15th.

Precipitation—Total, 8.40 inches; Greatest in 24 hours, 2.90; Dates, 28, 29.

Number of Days—With .01 inch or more precipitation, 14; Clear, 5; Partly cloudy, 17; Cloudy, 8.

Dates of—Killing frost, 19.

Meteorological Record: Month of October, 1907.

October, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	58	44	14	....	....	....	......	....	N. W.	Partly cloudy..
2	63	38	25	....	....	....	......	....	N. W.	Partly cloudy..
3	63	35	28	....	....	....	......	....	S. S. E.	Cloudy ....
4	68	49	19	Night	11.00	.65	......	....	N. W.	Partly cloudy..
5	64	34	30	12.00	6.00	.02	......	....	N. W.	Partly cloudy..
6	58	44	14	....	....	....	......	....	W.	Partly cloudy..
7	69	43	26	Night	Night	.11	......	....	S. S. E.	Partly cloudy..
8	67	42	25	Night	Noon	.87	......	....	N. W.	Partly cloudy..
9	57	33	24	....	....	....	......	....	S. S. E.	Clear............
10	52	27	25	....	....	....	......	....	S. E.	Clear............
11	56	41	15	....	....	....	......	....	S. E.	Partly cloudy..
12	63	44	19	....	....	....	......	....	W. S. W.	Partly cloudy..
13	60	36	24	....	....	....	......	....	N. E.	Partly cloudy..
14	62	48	14	....	....	....	......	....	N. W.	Partly cloudy..
15	55	32	23	....	....	....	......	....	N. W.	Clear............
16	65	34	31	....	....	....	......	....	W. S. W.	Clear............
17	73	35	38	....	....	....	......	....	S. W.	Clear............
18	68	43	25	....	....	....	......	....	N. W.	Partly cloudy..
19	44	32	12	....	....	....	......	....	N. W.	Partly cloudy..
20	44	27	17	8.00 a. m.	....	.02	......	....	W. N. W.	Cloudy ....
21	39	30	9	....	....	.23	......	....	W. N. W.	Clear............
22	56	23	33	....	....	....	......	....	S. W.	Partly cloudy..
23	54	42	12	....	....	....	......	....	N. W.	Partly cloudy..
24	46	35	11	....	....	....	......	....	N. W.	Partly cloudy..
25	51	20	31	....	....	....	......	....	W. S. W.	Partly cloudy..
26	47	28	19	....	....	....	......	....	N. W.	Clear............
27	48	19	29	....	....	Trace	......	....	S. S. E.	Partly cloudy..
28	67	57	10	....	....	.40	......	....	S. S. E.	Cloudy ....
29	54	39	15	....	....	1.13	......	....	N. W.	Cloudy ....
30	40	31	9	....	....	....	......	....	N. W.	Partly cloudy..
31	55	25	30	....	....	....	......	....	S. E.	Clear............
Sum	1747	1110	......	....	....	3.53	......	....	....	....
Mean	56.4	35.8	......	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

TEMPERATURE—Mean maximum, 56.4; Mean minimum, 35.8; Mean, 46.1; Maximum, 73; Date, 17; Minimum, 19; Date, 27; Greatest daily range, 38, on 17th.

PRECIPITATION—Total, 3.53 inches; Greatest in 24 hours, 1.13; Date, 29.

NUMBER OF DAYS—With .01 inch or more precipitation, 8; Clear, 8; Partly cloudy, 19; Cloudy, 4.

Meterological Record: Month of November, 1907.

November, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	58	23	35						S. S. E.	Clear
2	52	35	17	7.00	Morning	Trace			S. S. E.	Cloudy
3	52	48	4	Ni	ght	.65			W.	Partly cloudy
4	50	36	14						N. W.	Clear
5	46	23	23						S. S. E.	Clear
6	52	37	15	8.30	———	1.20			N. E.	Cloudy
7	52	40	12		4.00 p. m.	.50			S. W.	Cloudy
8	53	41	12						S. W.	Partly cloudy
9	56	29	27						S. S. W.	Clear
10	47	31	16	Night	6.00 p. m.	.45			S. S. W.	Cloudy
11	47	38	9						N. W.	Partly cloudy
12	39	21	18						N. W.	Clear
13	40	30	10						N. W.	Partly cloudy
14	37	25	12						N. W.	Clear
15	41	18	23						S. W.	Partly cloudy
16	44	18	26						S. S. E.	Clear
17	44	28	16						N. W.	Clear
18	44	21	23						S. W.	Partly cloudy
19	50	21	29						N. N. E.	Clear
20	43	26	17						E.	Clear
21	42	26	16			.12			E.	Cloudy
22	54	40	14			.02	2		E.	Partly cloudy
23	50	37	13			1.40			N. W.	Clear
24	44	30	14						N. E.	Cloudy
25	37	34	3						N. N. E.	Cloudy
26	40	32	8						N.	Cloudy
27	38	33	5			.04	½	½	N. N. W.	Partly cloudy
28	35	25	10			Trace			N. W.	Cloudy
29	38	27	11						N. W.	Clear
30	34	18	16						N. W.	Clear
Sum	1359	891				4.38	2½			
Mean	45.3	29.7								

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum—45.3; Mean minimum, 29.7; Mean, 37.5; Maximum, 58; Date, 1; Minimum, 18; Date, 15, 16, 30; Greatest daily range, 35, on 1st.

Precipitation—Total, 4.38 inches; Greatest in 24 hours, 1.4; Date, 23.

Snow—Total fall, 2½ inches; on ground 15th, none; at end of month, 1 inch.

Number of Days—With .01 inch or more precipitation, 8; Clear, 12; Partly cloudy, 9; Cloudy, 9.

Dates of—Thunderstorms, 6.

Meteorological Record: Month of December, 1907.

December, 1907.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	30	19	11	4.00 p. m.		Trace			N. N. W.	Cloudy
2	30	21	9	Night		.03			N. W.	Partly cloudy
3	33	20	13						N. W.	Clear
4	25	20	5	Night	2.00 p. m.	.05	1		N. W.	Cloudy
5	30	20	10						N. W.	Clear
6	38	23	13						N. W.	Clear
7	44	24	20						N. W.	Clear
8	44	17	27						N. W.	Clear
9	48	19	29						S. S. W.	Partly cloudy
10	62	41	21	Night	—	1.24			S.	Cloudy
11	50	40	10	—	Night	.14			S.	Partly cloudy
12	55	25	30						N. W.	Partly cloudy
13	33	25	8						N. W.	Partly cloudy
14	28	18	10	1.30	—	.35	3½	3½	N. E.	Cloudy
15	33	19	4	—	—	.53	5½	9	N. W. E.	Cloudy
16	34	26	8	—	Night	.03			N. W.	Cloudy
17	36	30	6						N. W.	Cloudy
18	37	28	9						N. W.	Partly cloudy
19	36	21	15						N. W.	Partly cloudy
20	39	20	19						S. W.	Cloudy
21	38	21	17						N. N. W.	Clear
22	45	16	29						S. S. W.	Clear
23	46	21	25	10.15	3.00	.45			N. E.	Cloudy
24	44	34	10						W.	Cloudy
25	40	24	16						S. W.	Cloudy
26	42	29	13						N. W.	Cloudy
27	44	17	27						W. S. W.	Cloudy
28	52	38	14						N. W.	Cloudy
29	37	27	10						W.	Clear
30	43	25	18	10.45	4.00	.77			W.	Cloudy
31	42	23	19						N. W. N.	Clear
Sum	1218	751				3.59	10			
Mean	39.3	24.2								

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 39.3; Mean minimum, 24.2; Mean, 31.7; Maximum, 62; Date, 10; Minimum, 16; Date, 22; Greatest daily range, 30, on 12th.

Precipitation—Total, 3.59 inches; Greatest in 24 hours, 1.24, Date, 10.

Snow—Total fall, 10 inches; on ground 15th, 9 inches: at end of month, none.

Number of Days—With .01 inch or more precipitation, 9; Clear, 9; Partly cloudy, 7; Cloudy, 15.

Dates of—Auroras, 22.

Meteorological Record: Month of January, 1908.

January, 1908.	Temperature.			Precipitation.					Prevailing wind direction.	Character of day.
	Maximum.	Minimum.	Range.	Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.		
1	41	22	19						W. N. W.	Clear
2	38	23	15						N. N. W.	Clear
3	32	22	10						N. W.	Clear
4	34	17	17						W. N. W.	Partly cloudy
5	36	12	24	6.00 p. m.	7.50 p. m.	.12			W. S. W.	Cloudy
6	33	8	25						W. N. W.	Partly cloudy
7	36	13	23			1.90			W.	Clear
8	50	33	17			.09			S. W.	Clear
9	39	25	14						N. W.	Partly cloudy
10	31	15	16						N. W.	Partly cloudy
11	37	12	25						N. W.	Partly cloudy
12	40	24	16	Night	——	1.17			N. N. E.	Cloudy
13	46	34	12						N. W.	Partly cloudy
14	36	15	21						N. W.	Partly cloudy
15	29	13	16						W. N. W.	Partly cloudy
16	40	31	9						N. W.	Partly cloudy
17	33	8	21						S. W.	Partly cloudy
18	37	27	10						W.	Clear
19	33	7	26						N. N. W.	Clear
20	31	1	30						S. W.	Partly cloudy
21	53	26	27						S.	Partly cloudy
22	53	38	15						W. N. W.	Clear
23	39	22	17						N. E.	Partly cloudy
24	24	9	15				T		N. E.	Cloudy
25	31	20	11						N. W.	Partly cloudy
26	41	27	14						S. S. E.	Partly cloudy
27	47	23	24			.16			W.	Partly cloudy
28	33	20	13			.04			N. W.	Partly cloudy
29	37	23	14						N. W.	Partly cloudy
30	20	−2	22						N. W.	Clear
31	16	−6	22						N. W.	Clear
Sum	1126	561				4.48				
Mean	36.3	18.1								

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 36.3; Mean minimum, 18.1; Mean, 27.2; Maximum, 53; Date, 21, 22; Minimum, −6; Date, 31; Greatest daily range, 30, on 20th.

Precipitation—Total, 4.48 inches; Greatest in 24 hours, 1.90; Date, 7.

Snow—Total fall, none; on ground 15th, none; at end of month, none.

Number of Days—With .01 inch or more precipitation, 6; Clear, 10; Partly cloudy, 18; Cloudy, 3.

Dates of—Auroras, 6.

Meteorological Record: Month of February, 1908.

February, 1908.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	44	36	8	....	....	....	......	....	W. S. W.	Cloudy.........
2	37	7	30	....	....	....	....	....	W.	Clear...........
3	22	2	20	....	....	....	......	....	W.	Partly cloudy..
4	23	-3	26	....	....	....	......	....	W. S. W.	Clear..........
5	16	-11	27	....	....	....	......	.. ....	W.	Partly cloudy..
6	34	18	16	Night	10.30	.66	6	6	E. N. E.	Cloudy.........
7	35	20	15	....	....	....	......	.... ..	W. N. W.	Partly cloudy..
8	31	-5	36	....	....	....	......	....	W.	Clear..........
9	15	-3	18	....	....	....	......	......	W.	Clear...........
10	33	-4	37	....	....	....	......	....	W.	Partly cloudy..
11	40	25	15	....	....	....	......	....	N. W.	Partly cloudy..
12	35	13	22	....	....	....	... ..	....	N. N. W.	Partly cloudy..
13	35	14	21	....	....	... .	.....	......	S. W.	Cloudy.........
14	46	34	12	....	....	....	......	....	E. S. E.	Cloudy.........
15	58	33	25	12.00 m.	———	.37	....	....	S. W.	Cloudy.........
16	55	27	28	....	....	Trace	......	....	W. N. W.	Partly cloudy..
17	35	19	16	....	....	.05	......	....	W. N. W.	Cloudy.........
18	25	14	11	....	....	Trace	......	. . .	N. W.	Clear..........
19	22	9	13	....	....	.94	7	7	N. N. E.	Cloudy.........
20	34	20	14	....	....	....	......	....	N. W.	Partly cloudy..
21	40	10	30	....	....	....	... ..	....	S. W.	Clear...........
22	33	18	13	....	. ...	....	......	....	N. W.	Clear......... .
23	25	-2	27	....	....	....	......	....	W. S. W.	Partly cloudy..
24	28	12	16	.. ..	....	....	.....	....	N. W.	Clear...........
25	30	-3	33	....	....	....	......	....	S. S. E.	Partly cloudy..
26	36	27	9	6.00 p. m	Night	.15	5	......	E. S. E.	Partly cloudy..
27	39	30	9	8.00 a. m.	5.00 p. m.	.31	......	....	N. W.	Cloudy.........
28	39	26	13	....	....	....	......	....	N. W.	Partly cloudy..
29	28	12	16	....	....	....	......	....	N. W.	Partly cloudy..
Sum	973	396	......	....	....	2.38	18	......	....	....
Mean	33.5	13.6	......	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

TEMPERATURE—Mean maximum, 33.5; Mean minimum, 13.6; Mean, 23.6; Maximum, 58; Date, 15; Minimum, —11; Date, 5; Greatest daily range, 37, on 10th.

PRECIPITATION—Total, 2.38 inches; Greatest in 24 hours, .94; Date, 19.

SNOW—Total fall, 18 inches; on ground 15th, none; at end of month, 7 inches.

NUMBER OF DAYS—With .01 inch or more precipitation, 6: Clear, 8: Partly cloudy, 13; Cloudy, 8.

Meteorological Record: Month of March, 1908.

March, 1908.	Temperature.			Precipitation.					Prevailing wind direction.	Character of day.
	Maximum.	Minimum.	Range.	Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.		
1	32	11	21	....	....	....	......	....	S.	Partly cloudy..
2	32	21	11	Night	———	.74	......	....	N. N. E.	Cloudy.........
3	35	18	17	....	....	Trace	......	....	N. W.	Cloudy........
4	32	17	15	....	....	....	......	....	E. S. E.	Partly cloudy..
5	33	16	17	....	....	....	......	....	S. S. W.	Partly cloudy..
6	31	8	23	3.30 p. m.	....	.10	......	6	S. E.	Cloudy.........
7	42	27	15	....	....	....	......	....	N. N. W.	Cloudy.........
8	41	27	14	....	....	....	......	....	W. S. W.	Partly cloudy..
9	42	23	19	....	....	....	......	....	N. N. W.	Partly cloudy..
10	24	11	13	....	....	....	......	....	N. W.	Clear..........
11	50	7	43	....	....	Trace	......	....	W. S. W.	Partly cloudy..
12	51	36	15	....	....	....	......	....	S.	Partly cloudy..
13	45	27	18	....	....	....	......	....	S.	Partly cloudy..
14	55	35	20	....	....	....	......	....	N. W.	Clear..........
15	56	31	25	7.00 p. m.	....	.03	......	....	S.	Cloudy.........
16	50	28	22	....	———	Trace	......	....	W. N. W.	Partly cloudy..
17	31	15	16	5.00 p. m.	....	.05	......	....	W.	Partly cloudy..
18	34	24	10	....	———	....	......	....	S. S. W.	Cloudy.........
19	41	31	10	Night	....	.17	......	....	N. W.	Partly cloudy..
20	34	25	9	....	....	....	......	....	N. W.	Partly cloudy..
21	41	14	28	....	....	....	......	....	N. W.	Clear..........
22	49	24	25	....	....	....	......	....	W. S. W.	Partly cloudy..
23	57	36	21	4.00 p. m.	....	.15	......	....	S.	Partly cloudy..
24	55	37	18	....	....	....	......	....	W. S. W.	Clear..........
25	42	20	22	....	....	....	......	....	N. W.	Clear..........
26	62	18	44	....	....	....	......	....	S. W.	Partly cloudy..
27	61	38	23	....	....	....	......	....	E. S. E.	Cloudy........
28	64	35	29	....	....	Trace	......	....	S. W.	Partly cloudy..
29	60	35	25	....	....	.30	......	....	N.	Cloudy.........
30	45	37	8	....	....	....	......	....	N. W.	Partly cloudy..
31	51	23	28	....	....	....	......	....	S. W.	Partly cloudy..
Sum	1379	755	......	....	....	1.54	......	......	....	....
Mean	27.0	14.8	......	....	....	....	......	......	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 27.0; Mean minimum, 14.8; Mean, 20.9; Maximum, 64; Date, 28; Minimum, 7; Date, 11; Greatest daily range, 44, on 26th.

Precipitation—Total, 1.54 inches; Greatest in 24 hours, .74; Date, 2.

Snow—Total fall, none; on ground 15th, traces; at end of month, none.

Number of Days—With .01 inch or more precipitation, 7; Clear, 5; Partly cloudy, 18; Cloudy, 8.

Dates of—Thunderstorms, 15, 29.

Meteorological Record: Month of April, 1908.

April, 1908.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	46	32	14	....	....	....	......	... ...	E.	Clear ....
2	45	30	15	Night	9.30	.13	.25	....	W. N. W.	Partly cloudy..
3	35	25	10	....	....	....	......	....	N. W.	Partly cloudy..
4	30	21	9	....	....	....	......	....	N. W.	Clear ....
5	50	30	20	....	....	....	......	....	S. W.	Clear ....
6	60	49	11	....	....	....	......	....	W. S. W.	Clear ....
7	61	46	15	....	....	....	......	....	N.	Clear ....
8	48	31	17	....	....	.65	......	....	E.	Cloudy.........
9	45	32	13	....	....	....	......	....	N. W.	Clear ....
10	63	28	35	....	....	....	......	....	S. W.	Partly cloudy..
11	61	37	24	10.00 a. m.	12.00 m.	Trace	......	....	W.	Partly cloudy..
12	45	37	8	....	....	....	......	....	N. W.	Clear ....
13	47	34	13	....	....	....	......	....	N. N. W.	Clear ....
14	50	28	22	....	....	....	......	....	S.	Clear ....
15	59	36	23	12.00 m.	5.30 p. m	.04	......	....	W. S. W.	Partly cloudy..
16	53	26	27	....	....	....	......	....	N. W.	Cloudy.........
17	52	20	32	....	....	....	......	......	N. W.	Partly cloudy..
18	57	28	29	3.00 p. m.	....	.13	......	....	N. E.	Cloudy.........
19	51	40	11	....	Night	.19	......	....	N. W.	Cloudy. ....
20	42	28	14	12.00 m.	3.30	Trace	......	....	N. W.	Cloudy.........
21	39	34	5	....	....	....	......	....	N. W.	Partly cloudy..
22	59	38	21	....	....	... .	......	....	W.	Partly cloudy..
23	80	45	35	....	....	....	......	....	E.	Partly cloudy..
24	59	40	19	....	....	....	......	....	S.	Partly cloudy..
25	57	39	18	....	....	....	......	....	N. E.	Partly cloudy..
26	82	50	32	....	....	....	......	....	W. N. W.	Partly cloudy..
27	72	50	22	....	....	....	......	....	S. S. E.	Partly cloudy..
28	51	43	8	Night	Night	.07	......	....	N. E.	Partly cloudy..
29	67	43	24	....	....	....	......	....	N. W.	Partly cloudy..
30	62	39	23	....	....	....	......	....	E.	Partly cloudy..
Sum	1618	1059	.....	....	....	1.21	......	......	....	....
Mean	53.7	35.3	.....	....	....	....	......	......	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maxinum, 53.7; Mean minimum, 35.3; Mean, 44.5; Maximum, 82; Date, 26; Minimum, 20; Date, 17; Greatest daily range, 35, on 10th and 23rd.

Precipitation—Total, 1.21 inches; Greatest in 24 hours, .65; Date, 19.

Number of Days—With .01 inch or more precipitation, 5; Clear, 9; Partly cloudy, 16; Cloudy, 5.

Meteorological Record: Month of May, 1908.

May, 1908.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	64	42	22	Night	Night	.19	......	......	W. S. W.	Partly cloudy..
2	60	31	29	2.30 p. m.	5.00 p. m.	.12	......	......	S. E.	Partly cloudy..
3	54	42	12	Night	12.30	.08	......	......	N.	Cloudy.........
4	52	41	11	....	....	....	......	......	S. E.	Partly cloudy..
5	60	48	12	....	....	....	......	......	....	....
6	50	42	8	....	....	....	......	......	....	....
7	46	40	6	....	....	....	......	......	....	....
8	50	48	2	....	Night	1.01	......	......	N. E.	Cloudy.........
9	62	44	18	Night	7.00 p. m.	.01	......	......	W.	Cloudy.........
10	57	46	11	....	....	Trace	......	......	N. W.	Partly cloudy..
11	79	62	17	....	....	....	......	......	W. N. W.	Partly cloudy..
12	85	61	24	3.00 p. m.	3.15 p. m.	.01	......	......	W.	Partly cloudy..
13	78	52	26	....	....	....	......	......	S. S. E.	Partly cloudy..
14	57	43	14	Night	1.30 p. m.	.42	......	......	W. S. W.	Cloudy.........
15	63	48	15	....	....	Trace	......	......	S. W.	Partly cloudy..
16	64	47	17	Night	Night	.01	......	......	S. S. E.	Cloudy.........
17	75	47	28	....	....	....	......	......	N. W.	Cloudy.........
18	74	52	32	....	....	....	......	......	S. S. E.	Clear ....
19	76	41	35	....	....	....	......	......	S.	Clear ....
20	68	42	26	....	....	Trace	......	......	S.	Partly cloudy..
21	73	52	21	....	....	Trace	......	......	S. E.	Partly cloudy..
22	59	52	7	Night	6.00 p. m.	.38	......	......	S. E.	Cloudy. ....
23	69	51	18	Night	Night	.21	......	......	S. E.	Partly cloudy..
24	82	57	25	....	....	....	......	......	S. E.	Clear ....
25	71	52	19	....	....	....	......	......	S. S. E.	Clear ....
26	91	45	46	....	....	....	......	......	S. W.	Clear ....
27	86	69	17	Night	Night	.01	......	......	W. N. W.	Clear ....
28	75	47	28	....	....	....	......	......	E.	Partly cloudy..
29	76	47	29	Night	Night	.03	......	......	E. S. E.	Partly cloudy..
30	71	52	19	3.30 p. m.	....	.19	......	......	E. N. E.	Cloudy.........
31	81	59	22	....	Night	1.87	......	......	S. W.	Partly cloudy..
Sum.	2108	1502	.....	....	....	4.54	......	......	....	....
Mean	68.	48.4	.....	....	....	....	......	......	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

TEMPERATURE—Mean maximum, 68.; Mean minimum, 48.4; Mean, 58.2; Maximum, 91, Date, 26; Minimum, 31; Date, 2; Greatest daily range, 46, on 26th.

PRECIPITATION—Total, 4.54 inches; Greatest in 24 hours, 1.87; Date, 31.

NUMBER OF DAYS..With .01 inch or more precipitation, 14; Clear, 00; Partly cloudy, 00; Cloudy, 00.

DATES OF—Killing frost, 4.

Meteorological Record: Month of June, 1908.

June, 1908.	Temperature. Maximum.	Minimum.	Range.	Precipitation. Time of beginning.	Time of ending.	†Amount.	Snowfall in inches.	Depth of snow on ground at time of observation.	Prevailing wind direction.	Character of day.
1	71	56	15	10.00 a. m.	....	.44	......	......	N. E.	Cloudy.........
2	67	40	27	....	....	....	......	....	N. W.	Clear ....
3	68	57	11	....	....	....	......	....	S. E.	Cloudy.........
4	74	48	26	....	....	.08	.....	....	E. S. E.	Partly cloudy..
5	64	48	16	....	....	....	......	....	E. S. E.	Clear ....
6	79	36	43	....	....	....	......	.. ....	S. W.	Clear ... .
7	88	47	41	....	....	....	......	....	W.	Clear ....
8	92	56	36	....	....	....	......	....	S. W.	Clear ....
9	90	62	28	....	....	....	.....	....	W.	Clear ... .
10	86	58	28	....	....	....	......	....	W. S. W.	Clear ....
11	76	54	22	....	....	....	......	....	W.	Clear ....
12	75	53	22	....	....	....	......	....	N. W.	Clear ....
13	84	51	33	....	....	....	......	....	S. E.	Clear ....
14	87	52	35	....	....	....	......	....	S. E.	Clear ....
15	80	61	19	....	....	....	......	....	S.	Partly cloudy..
16	71	57	14	5.00 a. m.	10.00 a. m.	.38	......	....	N. W.	Partly cloudy..
17	69	56	13	....	....	....	......	....	N. W.	Clear ....
18	80	39	41	....	....	....	......	....	W. N. W.	Clear ....
19	88	50	38	....	....	....	.....	....	S. W.	Clear ... .
20	89	70	19	....	....	....	... ..	....	W.	Clear ....
21	82	60	22	....	....	....	... ..	....	W.	Clear ....
22	80	55	25	....	....	....	......	......	W. N. W	Clear ....
23	73	57	16	....	....	....	......	.. ...	E. S. E.	Cloudy.........
24	77	56	21	3.00 a. m.	....	.05	......	....	E. S. E..	Cloudy.........
25	81	69	12	....	....	....	......	....	N. W.	Clear ....
26	80	51	29	....	....	..... .	......	....	S. E.	Clear ....
27	83	47	36	....	....	....	......	....	S.	Clear ....
28	79	55	24	....	....	....	......	....	S.	Clear ....
29	85	55	30	4.00 p. m.	5.00 p. m.	.01	......	....	S. S. W.	Cloudy.........
30	88	55	33	....	....	....	......	....	S. W.	Clear ....
Sum	2386	1611	......	....	....	.96	......	....	....	....
Mean	79.5	53.7	......	....	....	....	......	....	....	....

† Including rain, hail, sleet, and melted snow.

MONTHLY SUMMARY.

Temperature—Mean maximum, 79.5; Mean minimum, 53.7; Mean, 66.6; Maximum, 92; Date, 8; Minimum, 36; Date, 6; Greatest daily range, 43.

Precipitation—Total, .96 inches; Greatest in 24 hours, .44; Date, 1st.

Number of Days—With .01 inch or more precipitation, 5; Clear, 22; Partly cloudy, 3; Cloudy, 5.

METEOROLOGICAL SUMMARY.—1907-1908.

Months.	Average Temperature.			Precipitation.			Snow in Inches.			Number of Days .01 inch Precipitation.		
	July 1, 1895, to June 30, 1908.	1906-1907.	1907-1908.	Average, July 1, 1895, to June 30, 1908.	1906-1907.	1907-1908.	Average, July 1, 1895, to June 30, 1908.	1906-1907.	1907-1908.	Average, July 1, 1895, to June 30, 1908.	1906-1907.	1907-1908.
July	69.3	68.9	69.5	3.30	3.56	2.82	....	....	....	9	11	9
August	64.8	70.3	63.	2.90	2.87	1.54	....	....	....	8	10	8
September	59.9	61.9	61.	4.55	1.14	8.40	....	....	....	8	6	14
October	48.4	50.4	46.1	3.35	2.33	3.53	....	....	....	7	8	8
November	36.7	35.8	37.5	3.49	3.11	4.38	3.4	5.2	2.5	8	11	8
December	25.4	21.8	31.7	3.85	3.51	3.59	11.7	26.	10.	8	11	9
January	21.4	19.5	27.2	4.52	2.30	4.48	14.9	2.5	....	8	9	6
February	22.1	18.3	23.6	3.31	1.98	2.38	12.9	17.	18.	7	11	6
March	31.1	34.2	20.9	4.24	1.32	1.54	10.3	11.5	....	9	5	7
April	43.5	42.3	44.5	3.47	2.94	1.21	2.8	17.5	....	9	12	5
May	55.3	50.6	58.2	2.89	1.89	4.54	....	....	....	9	14	14
June	62.9	61.1	66.6	4.05	2.62	.96	....	....	....	9	11	5
Sum	540.8	535.0	549.8	43.92	29.57	39.37	56.0	97.7	30.5	99	119	99
Mean	45.1	45.6	45.8	....	....	....	....	....	....	....	....	....

PUBLICATIONS OF THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION, 1888—1908.

BULLETINS.

No. *1. Ensilage. Whitcher, G. H. Ap., 1888. 16p.
No. 2. Feeding experiments. Whitcher, G. H. June, 1888. 14p
No. 3. When to cut corn ensilage. Whitcher, G. H. July, 1888. 9p.
No. 4. The science and practice of stock feeding. Whitcher, G. H. Nov., 1888. 31p.
No. 5. Fertilizers and fertilizing materials. Whitcher, G. H. Mar. 1889. 18p.
No. 6. Experiments with fertilizers. Whitcher, G. H. Ap., 1889. 32p.
No. *7. Tests of dairy apparatus. Whitcher, G. H. Mar., 1889. 16p.
No. 8. Feeding experiments. Whitcher, G. H. Nov., 1889. 17p.
No. 9. Effect of food upon milk. Whitcher, G. H. Feb., 1890. 16p.
No. *10. Cooperative fertilizer experiments. Whitcher, G. H. Mar., 1890. 16p.
No. 11. Pig-feeding experiments. Whitcher, G. H. Nov., 1890. 14p.
No. 12. Fertilizer experiments. Whitcher, G. H. Mar., 1891. 13p.
No. *13. Effect of food on butter. Wood, A. H. and Parsons, C. L. May, 1891. 11p.
No. 14. Ensilage in dairy farming. Whitcher, G. H. May, 1891. 8p.
No. *15. Patent cattle-foods. Whitcher, G. H. and F. W. Morse. Dec., 1891. 7p.
No. 16. Effect of food on composition of butter fat. Morse, F. W. Sept., 1892. 20p.
No. 17. Stock feeders' guide. Whitcher, G. H. Oct., 1892. 13p.
No. 18. Effect of food on milk. Wood, A. H. Nov., 1892. 16p.
No. 19. Spraying apples and pears against fungi. Lamson, H. H. Feb., 1894. 13p.
No. 20. Effect of food on milk. Wood, A. H. Mar., 1894. 8p.
No. 21. Farm yard manures and artificial fertilizers. Whitcher, G. H. Apr., 1894. 16p.
No. 22. Prevention of potato blight. Lamson, H. H. May, 1894. 8p.
No. 23. Some dangerous fruit insects. Weed, C. M. Nov., 1894. 22p.
No. 24. Flow of maple sap. Wood, A. H. Feb., 1895. 9p.
No. 25. The composition of maple sap. Morse, F. W. and Wood, A. H. Mar., 1896. 13p.
No. 26. Analysis of fertilizers and wood ashes. Morse, F. W. Mar., 1895. 10p.
No. 27. Spraying experiments in 1894. Lamson, H. H. Ap., 1895. 16p.
No. 28. Remedies for the horn fly. Weed, C. M. June, 1895. 4p.
No. 29. Remedies for the flea beetle. Weed, C. M. June, 1895. 7p.
No. 30. An experiment in road making. Pettee, C. H. July, 1895. 19p.
No. 31. Seventh annual report. Murkland, Charles S. Nov., 1895. 24p.
No. 32. Studies of maple sap. Morse, F. W. Sept., 1895. 16p.
No. 33. Two shade tree pests. Weed, C. M. Nov., 1895. 9p.
No. 34. Surface and sub-irrigation out of doors. Rane, F. W. Aug., 1896. 27p.

---

* Out of print.

Bulletin.

No. *35. The codling moth and apple maggot. Weed, C. M. May, 1896. 6p.
No. 36. Analysis of three common insecticides. Morse, F. W. June, 1896. 4p.
No. 37. Crimson clover. Rane, F. W. July, 1896. 4p.
No. *38. The tent caterpillar. Weed, C. M. Aug., 1896. 15p.
No. 39. The army worm. Weed, C. M. Sept., 1896. 13p.
No. 40. Eight annual report. Murkland, C. S. Nov., 1896. 16p.
No. 41. Potatoes; varieties, fertilizers and scab. Rane F. W. and Hunt, Leigh. Feb., 1897. 10p.
No. 42. Tomato growing in New Hampshire. Rane, F. W. and Hunt, Leigh. Jan., 1897. 10p.
No. *43. Some inferior wood ashes. Morse, F. W. Feb., 1897. 5p.
No. 44. The canker worm. Weed, C. W. April, 1897. 10p.
No. 45. Fruit and potato diseases. Lamson, H. H. May, 1897. 11p.
No. 46. Experiments with a steam drill and methods of road maintenance. Aug., 1897. 29p.
No. *47. Strawberries in New Hampshire. Rane, F. W. Oct., 1897. 26p.
No. *48. Ninth Annual Report. Murkland, C. S. Nov., 1897. 30p.
No. *49. The inspection of fertilizers in 1897. Morse, F. W. Jan., 1898. 18p.
No. *50. Dehorning cattle. Lamson, H. H. and Rane, F. W. Feb., 1898. 9p.
No. *51. Sweet Corn in New Hampshire. Rane, F. W. Mar., 1898. 15p.
No. *52. Growing muskmelons in the North. Rane, F. W. Apr., 1898. 24p.
No. *53. The farm water supply. Morse, F. W. May, 1888. 11p.
No. *54. The winter food of the chickadee. Weed, C. M. June, 1898. 15p.
No. *55. The feeding habits of the chipping sparrow. Weed, C. M. July, 1898. 10p.
No. 56. Poisonous properties of wild cherry leaves. Howard, C. D. and Morse, F. W. Aug., 1898. 10p.
No. 57. Experiments with roots and forage crops. Rane, F. W. Sept., 1898. 28p.
No. *58. Cost of raising calves. Morse, F. W. Oct., 1898. 8p.
No. *59. Tenth Annual Report. Murkland, C. S. Nov., 1898. 53p.
No. *60. Green corn under glass. Rane, F. W. Jan., 1899. 16p.
No. *61. Inspection of fertilizers in 1898. Morse, F. W. Feb., 1899. 11p.
No. *62. Forcing pole beans under glass. Rane, F. W. Feb., 1899. 7p.
No. *63. Third potato report. Rane, F. W. Mar., 1899. 37p.
No. 64. Forest tent caterpillar. Weed, C. M. Apr., 1899. 22p.
No. *65. Notes on apple and potato diseases. Lamson, H. H. May, 1899. 10p.
No. 66. Experiments in pig feeding. Burkett, Chas. W. Sept., 1899. 15p.
No. 67. Spiny elm caterpillar. Weed, C. M. Oct., 1899. 15p. il.

---

*Out of print.

Bulletin.

No. 68. Eleventh Annual Report. Murkland, C. S. Nov., 1899. 49p.

No. 69. Inspection of fertilizers, in 1899 in co-operation with the state board of Agriculture. Morse, F. W. Jan., 1900. 14p.

No. *70. Experiments with muskmelons, Rane, F. W. Jan., 1900. 27p.

No. 71. Corn culture. Buckett, C. W. Feb., 1900. 12p.

No. 72. Insect record for 1899. Weed, C. M. Feb., 1900. 14p.

No. *73. Experiments with tomatoes and potatoes. Rane, F. W. Mar., 1900. 11p.

No. 74. Growing strawberries in New Hampshire. Rane, F. W. Apr., 1900. 20p.

No. 75. The forest tent caterpillar. Weed, C. M. May, 1900. 26p.

No. 76. Utilizing the green house in summer. Rane, F. W. June, 1900. 10p.

No. 77. Experiments in road surfacing. Pettee, C. H. Sept., 1900. 15p.

No. 78. Bovine tuberculosis. Lamson, H. H. Oct., 1900. 17p.

No. 79. Twelfth Annual Report. Murkland, C. S. Nov., 1900. 38p.

No. 80. Inspection of fertilizers in 1900. Morse, F. W. Jan., 1901. 8p.

No. *81. Insect record for 1900. Weed, C. M. Feb., 1901. 12p.

No. 82. Feeding farm horses. Burkett, C. W. July, 1901. 25p.

No. 83. The value of meadow muck. Morse, F. W. Aug., 1901. 4p.

No. 84. Forcing dwarf tomatoes under glass. Rane, F. W. Sept., 1901. 10p.

No. 85. Remedies for the canker-worm. Weed, C. M. Oct., 1901. 10p.

No. 86. Growing watermelons in the north and classification of watermelons. Rane, F. W. Nov., 1901. 30p.

No. 87. Thirteenth Annual Report. Murkland, C. S. Nov., 1901. 25p.

No. 88. Inspection of Fertilizers in 1901. Morse, F. W. Jan., 1902. 11p.

No. 89. The Squash Bug. Conradi, A. F. and Weed, C. M. Feb., 1902. 15p.

No. 90. Insect record for 1901. Weed, C. M. Mar., 1902. 16p.

No. 91. Killing woodchucks with carbon bisulphide. Weed, C. M. May, 1902. 4p.

No. 92. Silage studies. Morse, F. W. Sept., 1902. 14p.

No. 93. The cold storage of apples. Morse, F. W., and others. Oct., 1902. 25p.

No. 94. Remedies for fleas. Conradi, A. F. Oct., 1902. 4p.

No. *95. How to grow a forest from seed. Rane, F. W. Nov., 1902. 14p.

No. 96. Fourteenth Annual Report. Murkland, C. S. Nov., 1902. 31p.

No. *97. Inspection of fertilizers in 1902. Morse, F. W. Jan., 1903. 12p.

No. *98. The inspections of feeding stuffs for 1902. Morse, F. W. Feb., 1903. 23p.

---

*Out of print.

Bulletin.

No. 99. A selected list of vegetables for the garden. Rane, F. W. March, 1903. 18p.

No. *100. White fly of greenhouse. Conradi, A. F. and Weed, C. H. March, 1903. 8p.

No. 101. Fungous diseases and spraying. Lamson, H. H. Apr., 1903. 12p.

No. 102. Insect record for 1902. Weed, C. M. May, 1903. 10p.

No. 103. Standard milk. Morse, F. W. Oct., 1903. 4p.

No. 104. Fifteenth Annual Report. Nov., 1903. 15p.

No. 105. Fruit growing with a selected list of varieties. Rane, F. W. Jan., 1904. 24p.

No. 106. Forestry. Rane, F. W. Feb., 1904. 16p.

No. *107. Brown-tail moth in New Hampshire. Weed, C. M. Feb. 1904. 15p.

No. 108. Inspection of fertilizers in 1903. Morse, F. W. Mar., 1904. 10p.

No. 109. The pernicious or San Jose scale insect in New Hampshire. Weed, C. M. Mar., 1904. 10p.

No. 110. Experiment in orchard management in New England. Rane, F. W. March, 1904. 21p.

No. 111. Ten experiments with potatoes and potato culture. Rane, F. W. and Hall, H. F. April, 1904. 23p.

No. 112. Experiments in destroying black-flies. Weed, C. M. May, 1904. 8p.

No. 113. Corn meal, middlings, and separator skim-milk for fattening pigs. Oct., 1904. 7p

No. 114. Babcock test for New Hampshire farmers. Weld, I. C. Nov., 1904. 13p.

No. *115. Sixteenth Annual Report. Dec., 1904. 19p.

No. 116. The inspection of feeding stuffs. Morse, F. W. Jan., 1905. 8p.

No. 117. Inspection of fertilizers in 1904. Morse, F. W. Jan., 1905. 8p.

No. 118. Tile drainage. Taylor, F. W. March, 1905. 32p.

No. 119. Forestry. Rane, F. W. Mar., 1905. 20p.

No. 120. Dairy industry in New Hampshire. Weld, I. C. Sept., 1905. 10p.

No. 121. Gypsy moth. Sanderson, E. D. Dec., 1905. 22p.

No. *122. Brown-tail moth in New Hampshire. Sanderson, E. D. Feb., 1906. 28p.

No. *123. Inspection of fertilizers in 1905. Morse, F. W. Feb., 1906. 8p.

No. *124. Inspection of feeding stuffs in 1905. Morse, F. W. Mar., 1906. 8p.

No. 125. Vegetable novelties. Rane, F. W. and Hall, H. F. Mar. 1906. 28p.

No. 126. The care of composite milk samples. Weld, I. C. Apr., 1905. 4p.

No. 127. The feeding of farm stock. Taylor, F. W. Sept., 1906. 24p.

No. *128. Brown-tail and gypsy moth. Sanderson, E. D. and Howard, L. O. Jan., 1907. 22p.

---

*Out of print.

Bulletin.

No. 129. The Seventeenth and Eighteenth Annual Reports. Jan., 1907. 44p.

No. 130. Inspection of fertilizers. Morse, F. W. Feb., 1907. 8p.

No. 131. Spraying the apple orchard. Sanderson, E. D., and others. April, 1907. 48p.

No. 132. A plan for improving the quality of milk and cream furnished to New Hampshire creameries. Weld, I. C. May, 1907. 11p.

No. 133. Inspection of feeding stuffs in 1907. Morse, F. W. Nov., 1907. 8p.

No. 134. Fertilizer analyses, 1907. Morse, F. W. and Curry, Bert E. Dec., 1907. 8p.

No. 135. The respiration of apples and its relation to their keeping. Morse, F. W. Feb., 1908. 8p.

No. 136. Gypsy and Brown-tail moths. Sanderson, E. D. Feb., 1908. 63p.

No. 137. Strawberries for New Hampshire. Hall, H. F. May, 1908. 36p.

No. 138. Humus in New Hampshire Soils. Morse, F. W. June, 1908. 13p.

No. 139. Caterpillars injuring apple foliage in late summer. Sanderson, E. D. July, 1908. 22p.

No. 140. Analyses of feeding stuffs and fertilizers. Morse, F. W., and Curry, B. E. Dec. 1908. 16p.

Annual Reports.

†First Annual Report 1889. In the Eighteenth Report of the Board of Trustees of the New Hampshire College of Agriculture and Mechanic Arts. 1889. 99p.

†Second Annual Report 1890. In the Nineteenth Report of the Board of Trustees of the New Hampshire College of Agriculture and Mechanic Arts. 1890. p. 77-172.

Third and Fourth Annual Reports 1891-1892. In the Twentieth Report of Board of Trustees of the New Hampshire College of Agriculture and Mechanic Arts. 1893. p. 137-287.

Fifth Annual Report 1893. In the Twenty-first Report of the Board of Trustees of New Hampshire College of Agriculture and Mechanic Arts. 1893. p. 85-241.

Sixth Annual Report 1894. In the Twenty-second Report of the Board of Trustees of New Hampshire College of Agriculture and Mechanic Arts. 1894. p. 118-173.

All subsequent reports of the Station appear as Bulletins. See Bulletin list.

Technical Bulletins.

No. 1. An annotated catalogue of the butterflies of New Hampshire. Fiske, W. F. 1901. 80p.

No. *2. Classification of American muskmelons. Rane, F. W. Mar., 1901. 32p.

No. 3. Food of the Myrtle warbler. Weed, C. M. and Ned Dearborn. Nov., 1901. 32p.

---

*Out of print.

†Also published separately.

Technical Bulletins.

No. *4. Effect of acetylene gas-light on plant growth. Rane, F. W. Oct., 1902.

No. 5. A partial bibliography of the economic relations of the North American birds. Weed, C. M. 41p.

No. 6. A study of the parasites of the American tent caterpillar. Fiske, W. F. 1903. 58p.

Nature Study Leaflets.

No. 1. Pollination of flowers. Weed, C. M. 1902. 12p.

No. 2. Mission of the birds. Weed, C. M. 1902. 8p.

No. 3. Plant travellers. Weed, C. M. 1902. 8p.

No. *4. New Hampshire wild flowers. Weed, C. M. 1903. 16p.

School Bulletins.

No. 1. Agricultural education through rural schools. Sanderson, E. D. 1908. 20p.

No. 2. Soil studies. Taylor, F. W. 1908. 22p.

No. 3. Seeds and seedlings. Brooks, C. 1908. 14p.

Circulars.

No. 1. Mixing chemical fertilizers on the farm. Morse, F. W. 1908. 4p.

No. 2. Testing soils for fertilizer needs. Taylor, F. W. 1908.

No. 3. The apple leaf-aphis. Sanderson, E. D. 1908. 6p.

No. 4. Oyster-shell scale. 1908. 4p.

No. 5. San Jose Scale. Sanderson, E. D. 1908. 12p.

No. 6. A circular of information concerning the New Hampshire Agricultural Experiment Station. 1908. 16p.

No. 7. Some essentials in farm butter-making. Rasmussen, F. 1908. 2p.

---

*Out of print.

INDEX TO THE PUBLICATIONS OF THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION.

1888—1908.

BULLETINS 1 TO 140.

REPORTS 1 TO 20.

All black face type numbers refer to Bulletins; **C**—Circulars; **T**—Technical Bulletins; **NS**—Nature Study Leaflets; **S**—School Bulletins. Roman numerals refer to Biennial Reports of the New Hampshire College of Agriculture and the Mechanic Arts.

A

B

C

D

E

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y

Z

INDEX TO THE ILLUSTRATIONS IN PUBLICATIONS OF THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION.

1889—1908.

Bulletins 1 to 40. Reports 1 to 20.

All black face type numbers refer to Bulletins; C—Circulars; T—Technical Bulletins; NS—Nature Study Leaflets; S—School Bulletins. Roman numerals refer to the Biennial Reports of the New Hampshire College of Agriculture and the Mechanic Arts.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

V

W

Y

Z

BULLETINS 130 TO 140

OF THE

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

AND THE

NINETEENTH AND TWENTIETH ANNUAL REPORTS

NOVEMBER 1, 1906 TO NOVEMBER 1, 1908

NEW HAMPSHIRE COLLEGE
OF
AGRICULTURE AND THE MECHANIC ARTS
DURHAM, N. H.

TABLE OF CONTENTS.